# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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### OCTOBER 1924.

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## GENERAL PHYSICS.

**2381.** *Optical Study of the Diffusion in Liquids.* **B. W. Clack.** (Phys. Soc., Proc. 36. pp. 313–335; Disc., 335, June, 1924.)—The solution is contained in a parallel sided glass cell with a slow flow arrangement, so that the concentration varies from saturation at the bottom to zero at the top, and can be maintained at a steady state. Monochromatic light is rendered parallel, passes through two fine horizontal slits in a screen which is capable of vertical adjustment. After traversing the diffusion cell normally, the light is brought to a focus, where the image is viewed with a micrometer eye-piece. The image consists of a series of horizontal interference bands. The slits and eye-piece are alternately moved, the slits a definite number of fringes and the eye-piece to bring the zero fringe on to the cross wire again. For the determination of the coefficient of diffusion corresponding to any concentration four quantities have to be determined—the mass diffusing through the cell in the steady state, the rate of change of refractive index with the distance down the cell, the rate of change of the refractive index with concentration and density, and concentration at any point in the cell. The optical method devised gives the second of these quantities, and in combination with interferometer determinations of the third gives the fourth by calculation. The first quantity can be obtained by the analysis of the outflowing solution.

The coefficient of diffusion in some cases passes through a minimum, and increases towards Nernst's theoretical value for zero concentration. Although such a minimum has been expected by Arrhenius, care has been taken to eliminate the possibility of an end effect due to stirring. That this does not occur is proved by using a dilute solution at the flow end of the cell. In this case no minimum is observed. A. Wh.

**2382.** *Adsorption of Air by Various Kinds of Charcoal.* **J. Sameshima and K. Hayashi.** (Tohoku Univ., Sci. Reports, 12. pp. 289–298, Jan., 1924. In English.)—The bulk density of lump charcoal may be measured by smoothing the surface of the material by means of a file and sand-paper, painting the surface with a fat, such as lard, to prevent direct contact of the water with the charcoal, and weighing in air and water in the usual way. For bamboo charcoal the value 0·48 is thus obtained for the bulk density and for coconut-shell charcoal 0·98.

Measurements have been made of the adsorptive power of charcoal of various kinds for air at − 185°, − 79°, 0°, and room-temperature, the values found being usually greater with the wood charcoals than with bone black or sugar charcoal. The volumes of air adsorbed (at N.T.P.) by 1 gram or 1 c.c. of charcoal at a pressure of 1 atmosphere are expressed approximately by $v = k(1 - 0{\cdot}0062\mathrm{T} + 0{\cdot}00002\mathrm{T}^2)$, where $k$ is a constant for the particular kind of charcoal. The volumes of air adsorbed by 1 c.c. of wood charcoals are, except in certain cases, roughly proportional to the bulk densities of the charcoals. T. H. P.

**2383.** *Theory of the Adjustment of Levels.* **T. F. Connolly.** (Journ. Sci. Instruments, 1. pp. 257–264 June, and pp. 289–295, July, 1924.)—The paper considers briefly the principles on which the use and adjustment of modern levels depend. Levels are considered as belonging to two distinct types. The first type is adjusted to and depends on a highly accurate "centre." The second is independent of high centre accuracy, as each observation is "set to bubble." Both types are further subdivided as to whether or not they are "self-adjusting." A decided verdict is given in favour of modern levels "set to bubble" which are self-adjusting by means of a reversible bubble. In these instruments true level is indicated as the mean of two observations. This true level is quite independent of errors of setting up or adjustment of the instrument. [See also Abstract 1348 (1924).] AUTHOR.

**2384.** *Density of Liquids and their Temperature.* **J. J. Saslawsky.** (Zeits. phys. Chem. 109. 1–2. pp. 111–135, 1924.)—With a number of liquids the relation between the density and the temperature over a wide range of conditions is expressed very accurately by the equation, $\delta_t = \delta_k + \sqrt{\beta \mathrm{T}}$, where $\delta_t$ and $\delta_k$ are the respective densities at the temperature of observation and the critical temperature, $\beta$ is an empirical coefficient, and T the temperature of observation calculated from a certain empirical temperature, $\mathrm{T}_1$, so that $\mathrm{T} = \mathrm{T}_1 - t$. With alcohols, as might be expected, the agreement of the observed results with the above formula is not so satisfactory as with other compounds, but with liquid carbon dioxide the agreement is very close.

Since the mean value of $\delta_0 : \delta_k$, as given by Young, is 3·73, the above equation is convertible into the form $\delta_t = \delta_k\left(1 + \frac{2{\cdot}73}{\sqrt{\mathrm{T}_0}}\sqrt{\mathrm{T}}\right)$, or, for one and the same liquid at different temperatures, $\delta_t = \delta_k(1 + \alpha\sqrt{\mathrm{T}})$, $\alpha$ representing the degree of contraction, which remains almost constant from the lowest temperatures to the critical point. These two more general formulæ do not correspond exactly with the observed results, since $\delta_t$ depends, not solely on T, but also on the pressure; the agreement is enhanced if T is measured, not from $\mathrm{T}_k$, but from $\mathrm{T}_0 = \mathrm{T}_k + 0{\cdot}05\mathrm{T}_k$. The results then yielded by the formulæ agree closely with Young's experimental data. The formulæ may be used for calculating the value of $\delta_k$ from the values of $\delta_t$ and $\mathrm{T}_k$, which are the more readily determinable. T. H. P.

**2385.** *Graphical Methods of Calculation.* **C. Runge.** (Zeits. techn. Physik, 5. 5. pp. 141–165, 1924. Paper read before the Deutsch. Gesell. f. techn. Physik, June, 1923.)—Describes graphical methods for linear and quadratic interpolation, for the evaluation of rational functions, for the integration and differentiation of graphs and the integration of linear differential equations of the first order. Indicates the advantages and limitations of such methods. G. A. S.

**2386.** *Internal Friction in Glass and Quartz Filaments.* **A. Pazziani** and **C. E. Guye.** (Arch. des Sciences, 6. pp. 47–64, Jan.–Feb., and pp. 89–115, March–April, 1924.)—Lippmann's stroboscopic method gives accurate results. The logarithmic decrement of torsional oscillations gives a minimum at about 190° C. After a heating for two or three hours at 320° the log. dec. is smaller; after several hours at 650° the thermic variation of the log. dec. is reversible for glass; for quartz the same treatment at 800° produces a condition in which the variations of log. dec. are not the same with decreasing as with increasing temperature. The second modulus of elasticity undergoes sensible variations as the temperature passes from − 20° C. to 320° C. Connection between the thermic variations of log. dec. and allotropic changes, probably due to formation of tridymite crystals, orientated in all directions in isotropic material; or, in some instances, to the formation of crystoballite. A. D.

**2387.** *The Variation of the Coefficient of Sliding Friction with the State of the Surfaces in Contact.* **M. Fichter.** (Comptes Rendus, 178. pp. 1881–1882, June 2, 1924.)—The coefficient of friction is known to vary with the state of the surfaces in contact, and it is widely supposed that if the polish of the surfaces were continually improved a condition of movement without any friction at all would ultimately be reached. Measurements have been made by the author on various surfaces, such as iron on iron, brass on brass, copper on zinc, and steel on brass. It is found that the coefficient of friction at first diminishes as the surface is more perfectly polished, reached a minimum at a "critical polish," and then increases very rapidly. For the case of brass on brass, for example, the coefficient decreased to about 0·12, but eventually the separation of the two bodies required a normal force of 1·5 to 2 kg./cm.$^2$ With two such polished surfaces in contact, and with the aid of heat and of pressure, the bodies became practically welded together, so that in order to separate them parts of the surface were torn away. It is suggested that a theory of friction might be based on these results, the force of friction being supposed due to partial welding of the surface followed by a tearing apart of the particles, while fresh portions of the surface in contact become welded together. T. B.

**2388.** *The Theory of Fluid Crystals, particularly their Dielectric Constants and their Electrical Conductivity.* **L. S. Ornstein.** (Ann. de Physik, 74. 5. pp. 445–457, June, 1924.)—The paper is a theoretical discussion of the anisotropy of fluid crystals. A theory is developed for ascertaining the dielectric constant of a crystalline fluid in a magnetic field on (1) a molecular theory, (2) a crystal aggregation theory. The results thus obtained were compared with the practical results of Kast, and a complete agreement was found. The conclusions support the crystal theory mentioned above under (2). Tables are given in full illustration. Theoretical and practical experimental values for the electrical conductivity were deduced and are given. Finally, it is shown that the measurements of extinction of light made by Dr. Riwlin [Diss. Utrecht., 1923] for such fluids can be completely explained on the basis of the crystal theory above mentioned and fully discussed in the paper. S. G. B.

**2389.** *Viscosity of Gases at Low Temperatures.* **P. Günther.** (Zeits. phys. Chem. 110. pp. 626–636, 1924.)—The law of repulsion between molecules proposed by Nernst to explain the degradation of gases leads to the result that at low temperatures the viscosity is proportional to $T^{3/2}$, where T is the absolute temperature. Using the oscillating disc method this is verified for hydrogen. For helium the rate of fall of viscosity with T is also accelerated, but not in accordance with this law, although curves of the results seem to show that at still lower temperatures it would be true for helium; also Sutherland's formula fails completely at 20° abs. According to Chapman a quadratic term is neglected in its derivation, and the introduction of this brings it more into accord with the present measurements. But it then becomes physically meaningless at the lowest temperatures. Below 20° abs. it gives much too low a rate of fall of the viscosity. G. A. S.

**2390.** *Orientation of Surface Molecules and Surface-Tension.* **S. Sugden.** (Chem. Soc., J. 125. pp. 1167–1177, May, 1924.)—The Langmuir-Harkins hypothesis of the orientation of molecules on a liquid surface leads to the prediction of regularities in the total surface energy of benzene derivatives which are not verified by experiment. Even if the surface molecules of a liquid do possess a definite orientation, the total surface energy is not simply determined by those groups which are directed outwards, but by the molecule as a whole. A. D.

**2391.** *A Relation between Surface-Tension, Density and Chemical Constitution.* **S. Sugden.** (Chem. Soc., J. 125. pp. 1177–1189, May, 1924.) —Macleod's law [see Abstract 190 (1924)] is widely applicable. This is that, at any given temperature, $\gamma = C(D - d)^4$, where $\gamma$ is the surface tension, D is the density of the liquid, $d$ is the vapour density, and C is a characteristic constant independent of the temperature. Then if M be the molecular weight, $\{M/(D - d)\}\gamma^{1/4} = MC^{1/4}, = P$, which we may call the "parachor." In this $\{M/(D - d)\}$ reduces to the molecular volume when the temperatures are low; so that comparison of two P's is a comparison of molecular volumes at a temperature at which two $\gamma$'s have the same value. This is better than the ordinary method of comparison at boiling-points (equal vapour pressures). The expression $P = 0\cdot78V_c$ enables the critical volume, $V_c$, to be determined within 3%. But P can also be regarded as a function of chemical constitution. Data are given for 167 compounds. From these it appears that P can be predicted by the simple addition of atomic factors to factors corresponding to the chemical constitution, or conversely that the chemical constitution can be deduced from the values of P. The most probable values of P for C and H are then 4·8 and 17·4; the $CH_2$ difference in the value of P is 39. The boiling-point method, on the other hand, gives aberrant results. A. D.

**2392.** *Modified Vacuum Tubes.* **J. J. Manley.** (Phil. Mag. 48. pp. 110–112, July, 1924.)—Vacuum discharge tubes employed for the spectroscopic examination of gases at low pressures exhibit two defects, *viz.* insufficient luminosity of the feebler spectral lines and contamination of the gas by gases from the electrodes. In the forms of tubes designed by the author the former defect is eliminated by securing that radiation is emitted longitudinally in one direction only from the capillary employed, and the latter defect eliminated by the use of external electrodes. The life and reliability of tubes fitted with such electrodes, provided massive electrodes are employed and a complete absence of air-bubbles from the glass-electrode interface is secured, equal those of tubes employing internal electrodes. Means whereby these conditions may be satisfied are detailed, and three forms of tube embodying the devices are described. [See Abstract 262 (1924).] J. S. G. T.

**2393.** *Preliminary Measurement of a Primary Gas-grown Skin.* **J. J. Manley.** (Phys. Soc., Proc. 36. pp. 288–290; Disc., 293, June, 1924.)—A cylindrical glass vessel is filled with the gas to be investigated and maintained at a known temperature for a considerable time, so that the glass surface acquires a gas skin of maximum thickness. The vessel is then highly evacuated and maintained so until the daily increase of pressure on the vessel becomes inappreciable. A glow discharge is passed through the vessel between external electrodes, and serves to loosen and erupt the gas-grown skin. The resultant free gas is measured and the depth of skin calculated. It is shown that, in addition to the *secondary* skin removable by pumping, a glass surface possesses a *primary* and far more permanent skin. The minimum thickness of the normal air skin upon glass was found to be 20 molecules, a value considerably higher than that given by Langmuir and others. J. S. G. T.

**2394.** *Removal of Gas-grown Skins from a Sprengel Pump.* **J. J. Manley.** (Phys. Soc., Proc. 36. pp. 291–293; Disc., 293, June, 1924.)—A form of Sprengel pump having two vacuum tubes interposed between the cistern and the fall-tube is described. The vacuum tubes are provided with external electrodes, which, during the operation of the pump, are activated by an induction coil. The resulting glow discharges transform the skins on the inner surfaces of the pump into free gases, and the mercury, in falling through the discharge, is largely freed from condensed and absorbed gases. [See also Abstract 1467 (1922).] J. S. G. T.

**2395.** *Arrangement for Heating Electrically in Vacuo to a High Temperature.* **P. Lebeau and M. Picou.** (Comptes Rendus, 178. pp. 1151–1153, March 31, 1924.)—In the apparatus constructed by the authors the temperature is read in the interior of the heating-tube and in the immediate neighbourhood of the substance examined. The essential nature of the arrangement is a tube of carbon or of a refractory metal, molybdenum or tungsten, forming a resistance and placed in the interior of a vessel of Pyrex glass or of quartz, this tube connected at both its extremities with copper conductors formed of two concentric tubes, between which a current of cold water circulates. In each of these conductors the central tube, longer than the exterior, projects beyond it, and supports the heating-tube, with which contact is made certain by means of an inserted ring made of graphite or iron. The conductor and the tube make up a single cylinder extending along the horizontal axis of the furnace, connected on one side with vacuum tubes, and on the other fitted with a little sheet of glass, through which the interior can be observed. The joints are formed of Golaz mastic. With the object of obtaining reference points, the melting-points of molybdenum and tungsten have been observed and found to be respectively 2165° ± 25° and 2625° ± 25°. These are the apparent melting-points in an atmosphere of hydrogen and at atmospheric pressure. The temperature of the crater of the electric arc obtained by Lummer's method was found to be 3300° ± 25°.

The furnace described permits of electric heating in a vacuum to 2400°, and with it temperature can be evaluated to an approximation of 25°. J. J. S.

**2396.** *Research with High Vacua.* **W. R. Whitney.** (Gen. El. Rev. 27. pp. 430–439, July, 1924.)—A popular account is given of various experiments and apparatus in which a vacuum plays an important part. W. R. C.

**2397.** *Relations between the Atomic Concentration and the Mechanical, Thermal and Optical Constants of the Elements.* **P. Lasareff.** (Comptes Rendus, 178. pp. 1716–1718, May 19, 1924.)—If N represents the number of atoms of an element in a unit volume (atomic concentration), it can be shown that the modulus of elasticity E is proportional to $N^{4/3}$; for silver, zinc, copper, aluminium, cadmium, gold and tin this relationship holds very closely, the agreement in the case of lead being less satisfactory. Further, the latent heat of fusion is given by the expression, $Q_0 = b^2N$, where $b^2$ is a constant. Concordant results are given for lead, thallium, phosphorus, cadmium, gallium, silver, zinc and copper, but with platinum, palladium and iron the agreement is poor. The expression for the infra-red frequency of the atoms indicates proportionality between such frequency and $\sqrt{N/A}$, A being the atomic weight. Values of the frequency are available for lead, silver, zinc, copper and aluminium, and agree satisfactorily with this relationship.

If amorphous substances are indicated by the index *a* and crystalline substances by the index *c*, for one and the same element, $Nc > Na$ and hence $ANc > ANa$, so that the density of the crystals is greater than that of the amorphous element. Since, also, the hardness increases with N, it must be greater for the crystalline than for the amorphous element. When an amorphous substance undergoes conversion into the crystalline form, all the atoms should assume greater magnitude, and the electrons should pass from more remote orbits to others nearer to the nucleus. The radiation emitted by the electrons during such passage heats the substance, so that conversion of an amorphous substance to the crystalline form always produces a positive thermal effect. **Errata** (*ibid.* p. 1931, June 2, 1924). T. H. P.

**2398.** *Graphical Vapour Pressure and Specific Gravity Tables.* **H. C. Deming.** (Indust. and Engin. Chem. 16. pp. 614–615, June, 1924.)

**2399.** *Calibration for Trowbridge Pressure-recorders.* **C. Z. Rosecrans.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 783–786, June, 1924.)—The Trowbridge recorder is described in Abstract 808 (1923). The author gives a mechanical method of calibration. A. D.

**2400.** *A Simple Chemical Method for Testing the Efficiency of a Mechanical Stirrer.* **W. A. Roth.** (Zeits. phys. Chem. 110. pp. 57–59, 1924.)—A method of ensuring the efficiency of the stirring arrangement in a small bomb calorimeter (500 c.c. capacity) is described. The stirrer was rotated at different speeds in a calorimeter of circular section, the axis of the paddle being symmetrically placed with respect to the centre of the bomb. Below the middle of the bomb was fixed a capsule containing a small quantity of potassium permanganate, or the coloured salt was embedded in Glauber's salt. Samples of the water were withdrawn at definite intervals from various points of the calorimeter, and the amount of potassium permanganate in solution estimated. L. L.

**2401.** *Electric Pendulum.* **W. P. White.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 767–782, June, 1924.)—Describes a very accurate clock-pendulum of the electric gravity type, built with great ease. Simple equations are given showing how the design may be ordered to diminish the recognised errors inherent in the method of driving. These equations are used to discuss the value of this and other types of drive for pendulums of maximum accuracy, and indicate that the electric gravity drive equals, and possibly excels, the best of other types for such services. A. D.

**2402.** *A Slide-rule for Complex Numbers.* **J. Spielrein.** (Elekt. Zeits. 45. pp. 849–852, Aug. 7, 1924. Paper read before the Russian Eng., Moscow, 1921.)—The conversion of complex numbers from the form $a + jb$ to the form $r\epsilon^{j\theta}$ and *vice versa*, and the treatment of expressions involving products or quotients of complex numbers are problems of frequent occurrence in electrical theory. The arithmetical processes are rather laborious, and a suitable instrument would greatly lighten the work of calculation. The author describes first a system of superposed charts and graduated scales, which enable the arithmetic of complex quantities to be simplified, its use for conversion, multiplication and division being explained. The proper choice of the lengths of the scales and a discussion of the accuracy is given. The author then goes on to show how the device can be made up in the form of a slide-rule with three sliders ; this is more convenient but less accurate than the charts. Finally, it is suggested that a quite unimportant alteration to the slider of an ordinary slide-rule can adapt it for use in connection with complex quantities. B. H.

**2403.** *Moving-Wire Astrolabe.* **V. Michkovitch** and **E. Mallein.** (Comptes Rendus, 178. pp. 2167–2169, June 23, 1924.)—The astrolabe is one of M. Jobin's models, the modifications consisting of a micrometer (45 × 35 × 9 mm.), furnished with a mobile carriage (20 × 20 mm.) bearing a horizontal spider's web, the vertical displacement of the carriage being governed by an electric motor of continuous current of 10 volts, a screw pressing on a spring placed near the eye-piece and allowing the micrometer box to be turned on the telescope axis so as to get the micrometer wire into the horizontal position—which is fundamental to precise observation, and obtained in the same way as azimuth determinations in meridian instruments. The mercury bath is solidly attached to the instruments, and all precautions are taken against tremors. The authors describe the method of observation and give those obtained on two nights in June, 1924 ; the mean errors of these range from 0″·05 to 0″·10. A. S. D. M.

**2404.** *A Registering Micro-Photometer for Accurate Measurements.* **M. Siegbahn.** (Phil. Mag. 48. pp. 217–224, July, 1924.)—A form of registering micro-photometer in which the intensity of the radiation transmitted by a spectral plate in its different parts, or by any other medium, is determined by means of a thermopile is described. The galvanometer deflections are recorded on photographic plates, paper or film, and line distances may be determined with an accuracy of about 0·002 mm. [See also Abstract 291 (1914).] J. S. G. T.

**2405.** *Thomas Gas-Meter.* (Engineering, 118. pp. 182–183, Aug. 1, 1924.)—The fundamental principle of this instrument is based on the fact that the specific heat for all gases occurring in practice is very nearly constant. A heater unit constructed of transversely placed resistance wires is connected through a rheostat and a wattmeter to a source of current supply. In front of and behind this heater are placed resistance thermometers, forming the two arms on one side of a Wheatstone's bridge, two resistance coils making up the other sides. A galvanometer indicates when there is a balance, which exists when there is exactly 2° F. temperature difference between the gas at inlet and outlet, attainable by adjusting the two resistance coils. Compensation for water-vapour present in the gas to be measured is accomplished automatically by the nickel and manganese thermometers upsetting the bridge balance when too much water-vapour is carried in the gas, deflecting the galvanometer needle, which engages with a connection to a motor-driven regulator which it controls, thus causing the necessary adjustment of the heater to take place. T. C. H.

**2406.** *High-speed Camera for the Study of Projectiles in Flight.* **H. L. Curtis, W. H. Wadleigh** and **A. H. Sellman.** (Bureau of Standards, Technol. Papers, No. 255. pp. 189–202, Washington, 1924.)—The film is mounted on a drum, which is rotated at such a speed that the image of the projectile moves with the same velocity as the film. Several lenses are used, mounted on a line parallel to the axis of the drum, and uncovered successively by the rotation of another "focal plane" drum carrying a series of staggered slits. The rotation of the drum is checked by recording also a series of fine lines produced by a stroboscopic tuning-fork, as has hitherto been described. For any small number of lenses fifty exposures per second per lens is attained easily. The camera has been used for photographing the development of blast from a large gun, the penetration of armour plate by a shell, the yaw of a projectile, and the velocities of rotation and translation of a projectile in flight. A. Wh.

**2407.** *The Circular Dividing Engine of Edward Troughton,* 1793. **D. Baxandall.** (Optical Soc., Trans. 25. 3. pp. 135–139, 1923–1924.)

**2408.** *A Thermostat Regulator.* **E. Schreiner, J. Holtsmark** and **B. Trumpy.** (Zeits. Elektrochem. 30. pp. 293–295, June, 1924.)—A large copper resistance immersed in the bath whose temperature is to remain constant forms the fourth arm of a Wheatstone net. When the net is balanced the light reflected from the mirror of the very sensitive galvanometer used falls on a photo-electric cell. The cell is connected to a thermionic valve and a telephone relay in such a way that when it is excited it causes a glow-lamp in the bath to be lit. If the temperature of the bath rises the net is unbalanced, and the light is deflected so that it no longer affects the cell. This is a very sensitive arrangement, the difference between maximum and minimum temperatures over a period being only 0·0006 C. This is not regarded as the limit of sensitiveness that could be obtained. The temperature of the bath can be varied by suitable alteration in the ratio arms of the net. G. A. S.

**2409.** *Ionisation Manometer.* **H. Simon.** (Zeits. techn. Physik, 5. 6. pp. 221–233, 1924.)—The use of an ordinary three-electrode valve for the determination of the relations between the gas-pressure and the ionisation is discussed theoretically and experimental results described. The ionisation with the grid positive and anode negative is greater for a given positive voltage than with the grid negative and anode positive. The flow of positive ions is directly proportional to the pressure in all cases, provided that the flow of electrons is too small to produce glowing or that no saturation occurs owing to the current being too large or the gas-pressure too small. The manometer may be used to compare the rates of exhaustion of a vessel with different gases. It is shown that the specific emission of a tungsten filament is increased by the occlusion of gas. B. W. C.

**2410.** *Humidity Recorders.* **E. B. Wheeler.** (Bell System Techn., J. 3. pp. 238–258, April, 1924.)—The material effect of atmospheric conditions upon the operation of intricate electrical and mechanical apparatus, such as is found in telephone systems, is discussed, and the desirability of obtaining accurate information as to the character of the atmospheric conditions obtaining in typical localities is emphasised. The specific advantages and limitations of various well-known types of hygrometers are reviewed and the development of a new recording hygrometer is described in which the Leeds and Northrup automatic recorder is employed in conjunction with wet and dry bulb resistance thermometers in an auxiliary wind-tunnel equipment and a specially designed double Wheatstone bridge circuit. One of the Wheatstone bridges contains the dry bulb thermometer, the other containing both the dry and wet bulb thermometers. The satisfactory performance of a number of such instruments is illustrated in typical graphs. A new direct-reading humidity recorder is also described working on a similar general principle, and depending for its operation upon the approximate linearity and common intersection of the ordinary humidity curves connecting wet and dry bulb temperatures for a given relative humidity. A. B. C. L.

**2411.** *The Constants of the Polar Planimeter.* **A. Haerpfer.** (Zeits. Instrumentenk, 44. pp. 270–274, June, 1924.)—The paper contains a mathematical investigation of the two principal constants of the instrument which are connected with its mechanical adjustments. Although the polar planimeter has received much previous attention, yet for very accurate work this further study has been necessary. The theoretical results are supported by appropriate numerical data. H. H. Ho.

**2412.** *The Capillary Constant.* **I. I. Tichanowsky.** (Phys. Zeits. 25. pp. 299–302, June 15, 1924.)—Discussion of the mathematics of the method of pulling off a ring. A. D.

**2413.** *Measurements of Surface Tension, particularly by the Capillary Balance. The Surface Tension of Water.* **P. Lenard,** with **R. v.**

**Dallwitz-Wegener** and **E. Zachmann.** (Ann. d. Physik, 74. 5. pp. 381–404, June, 1924.)—The paper opens with a critical discussion of the various methods that have been used or proposed for use in surface-tension measurements. Results obtained by several observers by different methods show that the surface tension of water at 18° C. is about 7·4 mg./mm. The present paper contains details of confirmatory experiments made by the capillary balance or rupture method, this being the method considered most free from errors. In this a small rectangular framework of fine wire is immersed until its upper side is just above the surface of the liquid of which the surface tension is required; the frame is supported from a delicate spring balance. It is then depressed below the surface of the liquid, and on being again elevated the pull of the adherent film of liquid is observed; the surface tension is then calculable if the dimensions of the frame are known. The influence of the thickness of the wire forming the upper side of the frame (test wire) and the correction necessary for the effect of capillarity on the vertical sides are determined and allowed for. Accurate measurements of the length and diameter of the test wire and of the other relevant dimensions of the frame are recorded; wires of copper, iron, constantan, aluminium and brass were used. The weighings were done on a Hartmann and Braun spring balance. Results are given for the surface tension of an oil, for alcohol (2·34 mg./mm. at 23° C.), and finally for water (7·443 mg./mm. at 18° C.). The last result confirms earlier work of Zachmann by the same method. B. H.

**2414.** *Strength of Tungsten Single Crystals.* **Research Staff of General Electric Co., London.** (Phil. Mag. 48. pp. 229–249, Aug., 1924.)—By heating drawn tungsten wires to a high temperature large crystals are developed with random orientation of crystal axes, many of which occupy locally the complete volume of the wire. When these wires are subjected to a suitable tensile stress, some of these large crystals will be deformed by a process of slip and one will eventually fracture. The orientation of the crystal axis in this crystal is such that two sets of slip planes are symmetrically inclined to the direction of stress, and the crystal fractures in the form of a wedge symmetrical to the stress. This affords a simple means of studying the deformation of single crystals under conditions involving a minimum distortion of the crystal lattice. Results are given of the strength of such crystals in wires of various diameters and at temperatures varying from 700° K. to the melting-point. The time required for fracture is approximately an exponential function of the load and the temperature; for a given rate of deformation the load is proportional to the cross-sectional area, and, apart from transition temperatures, is a linear function of the temperature. Discontinuities occur in the load-temperature curves at temperatures approximately 850°, 1600°, and 2600° K. Variations in other physical properties occur at the same temperatures, and this leads to the view that these changes represent transformation points of a new type. Some new measurements on the thermal expansion of tungsten are recorded. C. O. B.

**2415.** *Approximate Solution of Two-Dimensional Elastic Problems.* **S. Timoschenko.** (Phil. Mag. 47. pp. 1095–1104, June, 1924.)—In two dimensional stress systems generated by corresponding boundary forces the stress components at any point can be derived from a single function $\phi$, which satisfies the equation $\nabla^2\phi = 0$. The solution of this equation with the specified boundary conditions is not always easy, and the author outlines an approximate method of obtaining the solutions by use of the double integral expression for the potential energy. Several examples are worked out in the paper to illustrate the use of the method.

G. W. DE T.

**2416.** *Tensile Properties of Aluminium at High Temperatures.* **T. Martin.** (Inst. of Metals, J. 31. 1. pp. 121–152; Disc. and Corres., 153–156, 1924.)—Tensile tests on two qualities of aluminium at temperatures up to the neighbourhood of the melting-point show a rapid diminution in strength with increase in ductility up to 325° C. At this point a marked increase in ductility takes place, attributed to a sudden increase in the rate of crystallization. With further rise of temperature the loss of strength continues at a less rapid rate. A comparison of the results for the cold-worked and fully annealed material indicates that up to 200° C. the added strength conferred by cold-work is well maintained, but at higher temperatures the rate of softening is such that the only reliable indication of strength is that obtained from a test on the fully annealed metal. The results show the importance of quantitative observations of the time and temperature conditions of annealing of a cold-worked metal as a preliminary to tensile testing at high temperatures. The tests on the less pure metal show that the effect of the impurities present is to make the metal stronger but less ductile at all temperatures, while the marked increase in ductility occurs at a temperature fully 75° higher. The maximum stress results obtained indicate that the time factor in tensile testing at all temperatures above the atmospheric is of greater importance than has hitherto been suspected.

C. O. B.

**2417.** *Duration of Impact of a Pair of Bars of Steel and of Copper.* **E. W. Tschudi.** (Phys. Rev. 23. pp. 756–759, June, 1924.)—The two bars to be tested were hung by bifilar suspensions, and the duration of impact (less than 0·0007 sec.) was measured for various impact velocities from records of the current through the surface of contact, made with a special heavy tungsten wire oscillograph with an undamped frequency of 16,000 per sec. The electrical resistance of the contact was shown to be independent of the velocity. The results for steel bars are from 10 to 20 % higher than those obtained previously with a condenser method of time measurement. The duration was the same for a bar 9 cm. long as for one of the same mass 62 cm. long. This seems to contradict the compressional wave theory. For two copper bars the duration came out 1·4 times that for steel bars of the same dimensions and velocity of impact, the ratio being the same as that of the velocities of sound in the two metals.

AUTHOR.

**2418.** *Optical Investigation of Stress Distribution.* **W. Birnbaum.** (Zeits. techn. Physik, 5. 4. pp. 143–149, 1924.)—A description of the apparatus is given which has been installed by the A.E.G. Turbine Department for investigating stress distribution by means of celluloid models and polarised light. The principle, developed by Coker and Asch, on which stress measurement is based, is explained in detail and the results of experiments on models representing the roots of turbine blading given exhaustively. It is shown that high local stress is produced at sharp corners in a section, and the values obtained experimentally with a "T" section model are correlated with those derived from theoretical considerations. J. V. H.

**2419.** *Analytical Discrimination of Elastic Stresses in an Isotropic Body.* **R. F. Gwyther.** (Phil. Mag. 44. pp. 274–283, July, 1922; 46. pp. 481–487, Sept., 1923, and 47. pp. 679–689, April, 1924.)—The author recalls the fact that G. B. Airy obtained from mechanical considerations (B.A. Reports, Cambridge, 1862) a solution in Cartesian coordinates of the mechanical stress equations. But he ignored all elastic requirements, and the objective of the author is to extend and supplement Airy's results. The method he employs is purely analytical, depending upon general solutions of the mechanical stress equations and upon the development of a scheme for the selection of those stress systems which satisfy the stress-strain relations, briefly called Hooke's law, from the general mechanical stress systems. The elements of a mechanical stress are shown to depend upon an arbitrary primary stress system, and in order to form a connection with the stress-strain relations the author introduces a subsidiary, but allied, stress system which is such that the vector system naturally deduced from it possesses inherent qualities distinctive of the displacement corresponding to an elastic stress system. The main body of the first paper consists in the discussion of the requirements necessary to ensure that the stress system should be an elastic one. According to this method the elements of stress are given prominence; the displacement, however necessary, appears as incidental, and there are no displacement equations. To begin with the author deals with a body under tractions only, and extends the results later. The mathematical development is simplified by first treating certain ancillary matters as lemmas. G. W. DE T.

**2420.** *Measurement of Internal Stress in Brass Tubing.* **R. J. Anderson** and **E. G. Fahlman.** (Bureau of Standards, Technol. Papers No. 257. pp. 229–241, 1924.)—A new method for measuring longitudinal internal stress in brass tubes, called the strip method, consists of slitting a narrow strip longitudinally—*e.g.* 2·75 in. long by 0·1 in. wide in a tube length of 3·25 in.—and then releasing one end of such strip by cutting. Stress is indicated by the springing out of the freed end, and can be calculated by a formula based upon the modulus of elasticity of the material and the distance in movement of the freed end. The method showed that in cold drawn brass tubes the major stress is longitudinal, that in the outer portion of the wall being tensile and that in the inner portion being compressive, the summation of the balanced stresses being zero. Absence of circumferential stress in tubes is indicated by the failure of diametrically cut rings to spring in or out on being slit in two. Experiments showed that the usual cutting methods which have been applied to bars and rods for the estimation of stress are not applicable to tubes, especially where the bulk of the stress is longitudinal. It has been thought that because cold drawn brass does not crack on application of an accelerating cracking agent it is free from internal stress; the strip method described is applicable for the quantitative estimation of stresses inferior to those necessary for cracking under the application of mercurous nitrate. C. O. B.

**2421.** *Propagation of Explosive Waves in Air.* **T. Vautier.** (Comptes Rendus, 179. pp. 256–259, July 28, 1924.)—Experiments are described which have been made in a pipe over a metre in diameter and several kilometres long in Lyons. The form of the pressure wave is measured by an interference arrangement. The wave passes through one of the light paths of a split lens interferometer, and the fringes are recorded on a moving photographic film. Hence all inertia effects are eliminated. The results are given for waves initiated by the combustion of a charge of black powder, a detonation of fulminate and the release of compressed air. The wave from the black powder shows a smooth rise to maximum initially, which later gives rise to a discontinuity. If the wave is translated into one of rarefaction by reflection at the open end of the tube, the form remains substantially unchanged during propagation. A detonation shows similar results, except that the discontinuity is initially present. The sudden release of compressed air shows a wave with successively diminishing condensations and rarefactions, no discontinuity being formed. It is pointed out that a discontinuity in any wave vanishes after reflexion at an open end. **A. Wh.**

**2422.** *Calculation of the Coefficient of Permeability of Clay from the Course of the Hydrodynamical Pressure Phenomena.* **K. v. Terzaghi.** (Akad. Wiss. Wien, Ber. 132. 2*a*. No. 3–4. pp. 125–138, 1923.)—The coefficient of permeability of a clay depends on the contained water, and this depends on the pressure to which the clay is subjected. In a former apparatus the clay was placed between two sand filter layers, and maintained at constant pressure. The water passed through the layer of clay from the lower to the upper side. The flow was produced by the difference of level between the surface of the overflow and the surface of the water in a vertical tube 6 mm. in diameter, and the coefficient of permeability $k$ was calculated from the velocity with which the water fell in the vertical tube. It was found that in clay with a porosity number $\epsilon < 2 \cdot 00$ and a coefficient of permeability $k > 0 \cdot 006$ cm. per year, there was no appreciable variation from the law of Darcy. In an investigation to determine the coefficient of permeability of loam and of clay in the viscous-plastic and in the semi-solid form, the direct method failed because the coefficient of permeability of the soils in this form was very small compared with $k = 0 \cdot 06$ cm. per year. A method was therefore developed in which the unavoidable errors of the direct method disappeared. The method consisted in the observation of the time change of the pressure phenomena in clay. By the hydrodynamical pressure phenomena the author means the delay which is caused in clay in the pressure, due to the resistance to the outflow of the squeezed-out pre-water. The permeability coefficient can be calculated from the time variation of the equalisation of pressure, as long as all other important factors are known.

The author now considers, with the help of diagrams, the case of a block of loam or clay of height $h$ contained in a vessel which will prevent spreading. As the pressure is increased, the pore number $\epsilon$ $\left(\epsilon = \frac{\text{volume of empty space}}{\text{volume of dry material}}\right)$ and the coefficient of permeability $k$ decrease, and a definite amount of water is squeezed out of the clay. The unit of volume is taken to be a prism of unit sectional area. The length of the prism in the direction of the pressure is variable and equal to $1 + \epsilon$, the reduced thickness $h$ of the layer is the thickness which the layer would have if the pore number were $= 0$, and the coefficient of permeability denotes the velocity of flow of the water through a layer of clay of the real thickness $1 + \epsilon$ when the difference of pressure height is 1 cm. The differential equation for the flow, *i.e.* $\frac{k}{a} \cdot \frac{\partial^2 w}{\partial z^2} = \frac{\partial w}{\partial z}$, which the author obtains, is easily integrated. This equation is exactly the same as that for the non-stationary propagation of heat in an isotropic medium. The solution of the equation is given and the results for special cases are plotted. The machine used by the author is so constructed that the compression may be kept constant while the pressure may be altered. He calculates the coefficient of permeability from the observed course of a change of shape, which may be compared to the adiabatic equalisation of temperature in a locally heated body. The value obtained for the coefficient of permeability, *i.e.* $1 \cdot 69 \cdot 10^{-7}$ cm. min.$^{-1}$, agrees well with the value $1 \cdot 65 \cdot 10^{-7}$ cm. min.$^{-1}$ obtained in 1919 by the direct method. The author concludes from his results that Darcy's law holds for the flow of water through loam in a semi-solid form. T. B.

**2423.** *The Airy Potential Function.* **W. Gauster.** (Zeits. techn. Physik, 5. 7. pp. 312–314, 1924.)—Plane problems in the theory of elasticity can be solved for the case where the mass forces fail or proceed only from the weight of the body itself by the introduction of the Airy potential function F to the integration of a partial differential equation of the form $\nabla^2\nabla^2 F = 0$. The most general case is now investigated whereby an entirely similar treatment is found to be possible. The paper is mathematical throughout. H. H. Ho.

**2424.** *A Spherical Source in a Rotating Liquid.* **S. F. Grace.** (Roy. Soc., Proc. 105. pp. 532–543, May 1, 1924.)—Consider a liquid rotating about an axis like a rigid body, and suppose, at a given instant, a spherical source, defined as a uniform discharge of liquid from the surface of a sphere of finite radius, to be suddenly generated relative to the rotating liquid, and then maintained, the centre of the source being on the axis. The author's problem is to determine the motion at any subsequent time on the assumption that the motion is small, *i.e.* that squares and products of velocity and vorticity components are negligible. This subsequent motion will be symmetrical with respect to the axis. The solution of the problem shows that the motion of the liquid along the axis is always away from the sphere. At a particular point the velocity oscillates with constant amplitude about a value equal to the velocity of discharge from the sphere, but increases with the distance therefrom until, at infinity, its value is equal to the velocity of discharge. The oscillation period decreases from an infinitely large value at the sphere to zero at infinity. The liquid has no motion across the plane through the centre of the spherical source perpendicular to the axis of rotation (the equatorial plane, say). The motion in the plane at any instant depends only on the distance from the centre of the sphere, and expressions for the radial and transverse components of velocity relative to the centre are obtained, which show that the motion tends rapidly to zero away from the sphere, a characteristic noted in previous problems [see Abstracts 626 and 2073 (1923)]. At a particular point the radial component of velocity tends to zero as time increases, oscillating about the zero value with diminishing amplitude, while the transverse component is opposite to the direction of rotation of the liquid and tends to become constant at a particular point. Thus the paths of particles in the equatorial plane tend to become circles concentric with the sphere. The motion becomes increasingly violent at the sphere in the vicinity of the equatorial plane. The existence of such violent motion shows that the solution will represent the actual motion of the liquid only for a limited time. It is found that the flow of liquid, due to the discharge from the sphere, is drawn out in the direction of the axis.

G. W. de T.

**2425.** *Resistance Experienced by Spheres in their Motion through Gases.* **P. S. Epstein.** (Phys. Rev. 23. pp. 710–733, June, 1924.)—A theory is developed first for the case where the droplets are small in comparison with the mean free path. Assuming the usual Maxwellian distribution of velocities in the gas, the force exerted by the impinging molecules is found to be $M = (4\pi/3)Nma^2c_mV$, $N$, $m$, $a$, and $c_m$ being respectively the number per unit volume, mass, radius, and mean speed of the molecules, and $V$ the speed of the droplet. The force exerted by the molecules leaving the surface depends on their manner of leaving. For uniform evaporation from the whole surface the force is $-M$; for specular reflection of all the impinging molecules, $-M$; for diffuse reflection with unchanged distribution of velocities, $-(13/9)M$; for diffuse reflection with the Maxwell distribution corresponding to the effective temperature of the droplet, $-(1 + 9\pi/64)M$ for a non-conducting droplet, and $-(1 + \pi/8)M$ for a perfectly conducting droplet. Of the first two cases, which cannot be distinguished experimentally, the second is more probable physically. The experimental values correspond to 10 % specular and 90 % diffuse reflection. The conditions at the surface of a comparatively large sphere are discussed, and it is shown that the diffusely reflected molecules have a Maxwellian distribution corresponding to the temperature and density of the gas. Bassett's assumptions are theoretically justified, and a confirmation is obtained for the correction factor for Stokes' law. In an appendix rotating spheres are considered, and the values of the resistance are derived for various cases.

A. B. C. L.

**2426.** *Molecular Fields and Cohesion.* **H. Chatley.** (Phys. Soc., Proc. 36. pp. 336–338; Disc., 338–339, June, 1924.)—The forces between the atoms or doublets in a solid can be assumed to be made up of an attraction varying as the inverse fourth power of the distance and a repulsion as the inverse tenth. It has been previously shown how to connect the resultant force between molecules and the stress-strain curves for solids, and expressions are derived from the variation of compressibility with pressure which are of an order agreeing with Bridgman's experimental results. Also, it appears that rupture of solids will occur for a linear extension of about 12 %, also in fair agreement with fact. *Discussion.*—**A. O. Rankine** expressed the opinion that the doublets would only attract according to the law assumed at distances much greater than those between molecules. Also Bridgman's experiments were on water, while the author's theory rests on crystal structure. **D. Owen** suggested that the methods developed in this paper permit speculation as to the conditions in the earth's interior.

A. Wh.

**2427.** *Euler's Knowledge of the Idea of Potential.* **R. Brenneke.** (Zeits. f. Physik, 25. 1. pp. 42–45, 1924.)—The object of this short paper is to show that Leonhard Euler introduced the concept of potential into hydrodynamical theory before the time of Laplace and Lagrange. References are given to Euler's work in 1736 in "Mechanica sive motus scientia"; in 1751, in "Histoire de l'acad. à Berlin"; and other journals. In 1755 he defined force potential in "Histoire de l'acad. à Berlin." In 1759 he gave the conditions for integrating the equations of motion ("Novi. comment. acad. ac. Petropolitanæ"). T. B.

**2428.** *Internal Pressures of Solids and Liquids.* **T. W. Richards.** (Frank. Inst., J. 198, pp. 1–27, July, 1924.)—If it can be assumed that changes of volume are the effects of changes of pressure, the change of volume in any chemical reaction should depend on the affinity of the reacting substances and on the compressibility of the materials. The general form of the expression indicating the equilibrium of the internal and external pressures is indicated, and is amplified as suggested by Grüneisen. The internal pressures of eighteen metals are tabulated. They vary from cæsium, 4000, to tungsten, 632,000 megabars. A bibliography of the author's work on atomic compressibility is given. A. Wh.

**2429.** *The Adiabatic Transformation of the Kepler Ellipse into the Harmonic Ellipse.* **H. Geppert.** (Zeits. f. Physik, 24. 3–4. pp. 208–246, 1924.)—In the present paper it is shown how different quantum states of a conditioned periodic system can be adiabatically transformed into one another. The transformation of the Kepler into the harmonic ellipse is accurately carried out by a rigid integration and quantelation of the initial, final, and a particular intermediate motion, which is characterised by the vanishing of the discriminant, as by treatment of the respective states. A complete unique transition into the periods determining the orbit has been established and is diagrammatically illustrated. The paper is entirely mathematical. H. H. Ho.

**2430.** *On the Course of the Motion and the Quantum States of Disturbed Kepler Motion.* **W. Lenz.** (Zeits. f. Physik, 24. 3–4. pp. 197–207, 1924.)—The object of this paper is to establish that the course of the disturbed Kepler motion is in many cases, inclusive of that of the simultaneous effect of an electrical and of a magnetic disturbing field orientated thereto in any given way, obtainable by elementary mechanics. Reference is made to the extension of Bohr's method to crossed fields by Klein [see Abstract 1380 (1924)]. The quantum conditions are now derived from knowledge of the frequencies of a disturbed motion regarded as multi-periodic and without recourse to the separation method. The case is then evaluated of the simultaneous action of an electric and magnetic field upon the H-electron. The paper is entirely mathematical.
H. H. Ho.

**2431.** *Approximate Calculation of the Orbits and Transition Probabilities of the Series Electrons in the Sodium Atom.* **W. Thomas.** (Zeits. f. Physik, 24. 3–4. pp. 169–196, 1924.)—Based on the Bohr theory of hydrogen and similar systems, the dynamics of the series electrons in the alkali metals is now worked out whereby the field of the atomic nucleus is regarded as the central field. The orbits and Fourier coefficients for the lines I, II and III of the sodium principal series are calculated, assuming Fues' hypothesis for the potential gradient in the sodium atom. Comparison is then made between the relationship of the calculated values of the transition probabilities and the absolute value of transition probability of the resonance line and the values which Ladenburg has derived from correspondence considerations and measurements of dispersion and magnetic rotation. Agreement has been found in the dimensional order. The paper is entirely mathematical. H. H. Ho.

**2432.** *The Electron Theory of Solids and the Rigidity of Metals.* **D. Banerji.** (Indian Assoc. for Cultivation of Science, Proc. 8. 3. pp. 199-216, 1923.)—This paper contains calculations of the coefficient of rigidity of the alkali metals on the basis of the atom model proposed by J. J. Thomson [see Abstract 277 (1923)], the results obtained being experimentally verified for sodium and potassium. The calculations include the cases of the apparently complex structures of the metals copper, silver and gold, which are generally considered to be related to the alkali metals in their monovalent character and the regular system in which they all crystallise. The calculations are extended to the case of the trivalent aluminium and divalent calcium, and good agreement is found between the calculated and the observed values for aluminium. It is assumed generally that the thermal motion of the electrons composing the atoms is nil, *i.e.* no account is taken of the temperature coefficient of the rigidity constants. H. H. Ho.

**2433.** *Electronic Orbits in the Alkali Metals.* **R. B. Lindsay.** (Journ. Math. Phys. Mass. Inst. of Technology, 3. pp. 191-236, May, 1924.)—A detailed calculation of the dimensions of the electronic orbits in the atoms of the alkali metals on the basis of Bohr's theory and with certain simplifying assumptions. It is assumed that each electron will influence the orbits of other electrons as if the charge were distributed over an infinite number of surfaces spherical about the nucleus, the charge contained between any two being proportional to the time during which the electron is contained between them. In general the orientation of the orbits is not considered. It is known that the outer portions of the orbits are similar in shape to Keplerian ellipses, and, since most of the time is spent by an electron in these outer portions, it is considered justifiable to take approximate values for the effective nuclear charge and the effective quantum number and assume such elliptic orbits as initial approximations. Diagrams of the orbits for the four alkali metals are given, and a value derived for the radius of the ions compared with figures of Grimm and Landé. A. Wh.

**2434.** *The Electrical Theory of Solid Bodies.* **J. Frenkel.** (Zeits. f. Physik, 25. 1. pp. 1-30, 1924.)—In the present entirely mathematical paper the electrical potential of an atom (or molecule) and the mutual potential energy of two such systems are developed generally in terms of negative powers of the distances apart, with coefficients (spherical functions) whose parameters are the electrical moments of these systems. It is established that in the case of like atoms constant phase differences must play a fundamental part, and that such phase relations may occur also in the case of different atoms by a mutual synchronisation of the outer electrons. Based on these principles, and on Landé's simplified cubic model of the carbon atom, the lattice theory for the diamond is developed, in which not only the lattice constants (dimensions, energy, compressibility), but also the lattice type, can be established. The same method is next applied to the simplest heteropolar union (of the rock-salt type), whereby, however, the results are not so quantitatively exact.

H. H. Ho.

**2435.** *Crystal Symmetry and Residual Radiation.* **C. J. Breater.** (Zeits. f. Physik, 24. 5–6. pp. 324–344, 1924.)—When the reflective capacity of a crystal is graphically expressed as a function of the frequency of the incident rays, a curve is found which, in most cases, exhibits different characteristic reflection maxima. By repeated reflection, fairly homogeneous ultra-red rays can be separated, to which the term residual (rest) radiation has been given. The present investigation relates to the oscillations of a physical point system composed of a finite number of electrically charged particles, and dependent on the symmetry characteristics. It is shown how the results may be evaluated for an infinite crystal lattice. Comparison of the measurements of the residual radiation of different crystals serves to confirm the theoretical results. The latter are then applied to the case of calcspar, six types of oscillation being considered. The conclusion is drawn that the ions of a space-lattice cannot be regarded as spherically symmetrical point-forming particles, but constitute a configuration of more complex structure, which influences to a greater degree the mutual forces the smaller the distances apart of the ions concerned.

H. H. Ho.

**2436.** *Values of the Magneton.* **P. Weiss.** (J. de Physique et le Radium, 5. pp. 129–152, May, 1924.)—Values of the magneton have been deduced from many sources, and it is shown that similar values are obtained from metals at low temperatures, paramagnetic gases, salt solutions, solid salts, metals below the Curie point and other materials. The magneton derived from these experiments is almost exactly one-fifth of that derived by classical theory from quantum considerations, and it is clear that the quintuple relation is an important one. Oxygen gas possesses 10 magnetons, while for the series of ions $V^{++++}$, $Cr^{+++}$, $Fe^{+++}$, in which the numbers of electrons increase by 2, the magnetons are 9, 19, 29, a difference of 10 in each case, or twice the quantum magneton. A completely satisfactory theory must explain the occurrence of this quantity apparently one-fifth the moment of the quantum magneton.

A. Wh.

**2437.** *On an Extension of the Adiabatic Hypothesis.* **K. Försterling.** (Zeits. f. Physik, 25. 4–6. pp. 253–264, 1924.)—The energy of a wave can be obtained adiabatically in two ways; (1) By adiabatic absorption at an atom and subsequent radiation emission; (2) by aid of a movable mirror to act direct upon the radiation in the free ether. On the assumption that both operations lead to the same result, an extension of the Ehrenfest adiabatic hypothesis is now made whereby the damping of waves can be studied which are emitted by an atom with or without a magnetic field. The correctness of the hypothesis is directly confirmed by the Doppler effect. The correspondence principle is modified by means of the frequency condition as follows; (1) No more frequencies are radiated than occur in the Fourier expansion of the initial or final orbit of the electron; (2) polarisation of these waves, as well as the connection between energy and rotation impulse, corresponds to that on

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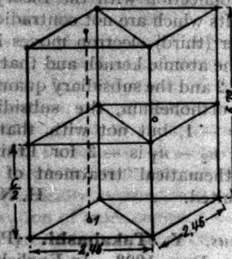
the classical theory; (3) the hypothesis of the conservation of rotation impulse is valid. On application of these hypotheses to the transition of an electron between two circular orbits of unit quantum difference, it follows from (1) that only one frequency is radiated, from (2) that this wave is circularly polarised in the ray direction perpendicular to the orbit plane, and from (3) $E = h\nu$, since $E/\nu$ is the rotation impulse of the wave, and $h$ is the emitted rotation impulse. **H. H. Ho.**

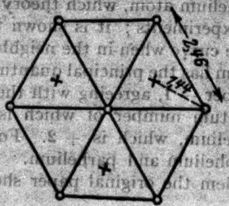
**2438.** *The p and d Terms of Lithium.* **F. J. v. Wiśniewski.** (Phys. Zeits. 25. pp. 330–333, July 1, 1924.)—The author makes use of the same mathematical method as he employed in connection with the theory of the helium atom, which theory leads to results which are not contradicted by experiments; it is shown that the outer (third) electron moves in a space curve when in the neighbourhood of the atomic kernel, and that the $p$ term has the principal quantum number $+ 2$ and the subsidiary quantum number $- 1$, agreeing with the $p$ term of orthohelium, the subsidiary quantum number of which is $(n_2 - n_1) = - 1$, but not with that of parhelium, which is $+ 2$. For the $d$ term $n_2 - n_1$ is $- 3$ for lithium, orthohelium and parhelium. For the mathematical treatment of the problem the original paper should be consulted. H. N. A.

**2439.** *Structure of the Helium Nucleus.* **Y. Takahashi.** (Phys. Math. Soc. Japan, Proc. 5. pp. 137–149, Oct.–Dec., 1923. In English.)—The nucleus of helium is assumed to consist of four protons in a circle and two electrons on the axis. The dimensions of the nucleus and the mass-decrement are calculated for the cases where either Coulomb's law or the quantum relation, or both, hold. To explain the observed stability of α-particles it is necessary to assume that Coulomb's law is not obeyed. From the probable form of the fields existing within the nucleus is deduced the relative probabilities of the formation of particles consisting of electrons and protons. These are written $e_iP_j$. In light elements the nucleus seems to consist of α-particles, $e_2P_3$, $e_2P_2$, $e_1P_2$ and protons, and a scheme showing the probable constituents of the nuclei of the elements up to vanadium is given. A. Wh.

**2440.** *The Relation Between the Crystal Structure and the Constitution of Carbon Compounds. Part II. Crystallography of Further Simple Substitution Products of Methane.* **I. E. Knaggs.** (Chem. Soc., J. 125. pp. 1441–1444, July, 1924.)—The following compounds have been examined: (1) Chlorobromoacetomethylamide, (2) chlorobromoacetoethylamide, (3) dichloroacetoethylamide, (4) dichloroacetomethylanilide, (5) dichloroacetomethylanilide; (1) crystallises in the orthorhombic system, and stands by itself, the others in the monoclinic system, Evans's II Uc (holohedral) class. The isomorphism of (2) and (3) is extremely close. There is a close similarity in the ratio of the axes $a$ and $b$ of (1), (2) and (3), but the ratio of $c$ and $b$ is considerably smaller for (1) than for (2) and (3); the angle β is nearly 90° in (2) and (3). Compounds (4) and (5) are isomorphous, though not so closely so as (2) and (3). It is hoped to continue the investigation with the aid of X-rays. H. N. A.

**2441.** *The Crystalline Structure of Graphite.* **O. Hassel** and **H. Mark.** (Zeits. f. Physik, 25. 4–6. pp. 317–337, 1924.)—By combining a number of different X-ray interference methods the lattice structure of graphite has been examined, using single crystals, artificial and natural, and polycrystalline material. A number of rays of different hardness were made use of. The smallest possible orthohexagonal elementary body has the dimensions $a = 2 \cdot 47$, $b = 4 \cdot 25$, $c = 6 \cdot 70$, and contains eight atoms. Consideration of the intensities of the interferences leads to a $c$-edge centred lattice, with the reflecting power $R_1$, shifted through 1/3 2/3 $p$ with respect to a closest packing with reflecting power $R_2$; $p$ lies between 0 and 0·1. The results of Ewald, Debye, Scherrer and Hull agree with this structure. Figs. 1 and 2 show the arrangement of the atoms, which are of two kinds, with different reflecting power, those indicated by black dots and those by small white circles. Hull's structure, in which all the $c$ atoms are crystallographically equivalent to one another, is not one of the theoretically possible cases. H. N. A.





**2442.** *The Crystal Structure of Argon.* **F. Simon** and **C. v. Simson.** (Zeits. f. Physik, 25. 2. pp. 160–164, 1924.)—The crystal structure of argon at a temperature of 40° abs. has been determined and found to be a face centred cubic lattice. The experimental arrangement was previously described [Abstract 1064 (1924)].

As a mean value for the lattice constant at 40° abs. $a = 5 \cdot 42 \pm 0 \cdot 02$ Å, whence the density $\rho = 1 \cdot 65 \pm 0 \cdot 02$, whereas the density of the liquid at the melting-point $\rho_{84°} = 1 \cdot 42$.

The "atomic radius" = 1·92 Å. The results are discussed in terms of the theory of the solid state to Mie, Born, and others on the assumption that each atom exerts attractive and repulsive forces on the neighbouring atoms, the forces being expressible in terms of simple distances and by potentials of reciprocal distances.

Thus the potential energy per cell $= \phi_0 = A/\delta^m - B/\delta^n$, and it is concluded that for solid argon $m = 9$ and $n = 15$, though the evidence is not conclusive. W. V. M.

**2443.** *Crystal Forms and Lattices.* **M. Yamada.** (Phys. Zeits. 25. pp. 289–296, June 15, 1924.)—The method of arriving at the surface energy of crystals developed in previous papers [Abstracts 336 and 1600 (1924)] is made use of in certain simple cases, under certain assumptions as to the action between the atoms, in order to ascertain whether the crystal forms which the theory indicates are really found in Nature. The simple cubical lattice (which does not occur among natural crystals, but which is mathematically interesting), the cubic face centred lattice, the cubic body centred lattice and the diamond lattice are dealt with, first on the assumption that each atom attracts only its immediate neighbours, and second that it also attracts or repels the next atom beyond each neighbour. The results obtained strictly hold for the case where the temperature is absolute zero and the crystal is formed in a vacuum. The effect of temperature will not probably greatly change the form of the crystal, but the nature of the surrounding medium is important; only when the crystal is formed by sublimation are the required conditions approximately fulfilled. Of five metals, Cu, Ag, Au, Pb and Fe, crystallised by sublimation, one, Pt, crystallised in incandescent wires, and the diamond, as prepared by Moissan, all except iron have forms and cleavages or slip surfaces which agree with the theory. Iron is, unfortunately, the only example in the above list of a cubic body centred lattice; but between 900° C. and 1410° C. it is cubic face centred, so that no certain conclusion can be drawn as to whether the metals have a homopolar or a heteropolar structure. H. N. A.

**2444.** *The Influence of Gravitation upon Light from the Standpoint of the Ether Theory.* **R. Hiecke.** (Zeits. f. Physik, 24. 2. pp. 117–120, 1924.)—The two actions of gravitation on light which are involved by the theory of relativity are considered on the basis of Maxwell's theory of light, and are treated on the assumption that the ether behaves as an incompressible liquid and in the neighbourhood of large masses experiences a very small increase of density. The deviation of a light ray obtained by the investigation is $\phi = 2KM/c_0^2 r_0$, where K is the gravitation constant, and M the gravitation mass, and $r_0$ the length of the perpendicular from the centre of the sphere considered to the path of the ray of light. J. J. S.

**2445.** *Criticism of the Relativity Theory from the Mathematical-Physical Standpoint.* **G. v. Gleich.** (Zeits. f. Physik, 25. 3. pp. 230–246, 1924.)—In this paper it is shown briefly how in the relativity theory the purely formalistic influences the physical content of the mathematical treatment. The author refers thereby to the notorious arbitrary character in Einstein's mathematical development which has hitherto been stressed too little. Section 1 deals with the system of reference, Lorentz transformation, and invariance. The special theory of relativity, though associated with physical experiment (Michelson), depends, however, solely on its formal mathematical interpretation by Lorentz. In consequence, the relativisation of time (dealt with in § 2) is not physically founded, but is only the result of a mathematical assumption. This applies in an enhanced degree to the general theory of relativity, which, moreover, is affected with arbitrariness. Sections 3, 4 and 5 deal with the perihelion abnormality, light deflection, and red displacement respectively, which are explained alternatively by at least equally valid means. H. H. Ho.

**2446.** *Gravitation and Newton's Third Law.* **G. Maneff.** (Comptes Rendus, 178. pp. 2159–2161, June 23, 1924.)—H. Poincaré (Electricité et Optique, 1901, p. 448.) has shown that Lorentz's electrodynamic theory violates Newton's third law. This led Abraham (Ann. d. Physik, 10. p. 105, 1903) to consider an electromagnetic quantity of motion. Hasenöhrl, admitting this, showed that the Lorentz contraction would follow [see Abstract 498 (1909)]. Finally, Planck introduced this quantity into general dynamics, assuming Newton's third law correspondingly generalised to apply to energy as well as to the inertia of matter [see Abstract 412

(1909)]. The author's objective is to determine the consequences of this generalisation, and applying to the energy and absolute time of classical mechanics. The result of the Michelson-Morley experiment, together with the Lorentz contraction in length and dilatation in time, then appear as consequences of the inertia of energy. Lorentz's local time becomes unreal—a mere parametric time. The classical relativity principle would therefore be inapplicable to ordinary mechanics. But, since $v^2/c^2$ is negligible for ordinary speeds, the Galilean transformations would remain valid. Moreover, the author shows analytically that when approaching a gravitational centre the speed of light would decrease proportionally to its rate of approach. G. W. DE T.

## METEOROLOGY AND GEO-PHYSICS.

**2447.** *Climatological Data of the West Indies.* (U.S. Dept. of Agriculture, 3. pp. 89–96, Dec., 1923.)

**2448.** *Investigation of the Dust Content of the Atmosphere.* **H. H. Kimball** and **I. F. Hand.** (Monthly Weather Rev. 52. pp. 133–139, March, 1924.)—Observations have been made with an Owens' dust counter at the American University and at the Weather Bureau, Washington. The number of particles observed at the University varied between 100 and 4000 per c.c., the average values being about 400 per c.c. during the summer and 850 during the winter; the number counted at the Weather Bureau was greater in each period. The dust content in the winter of 1922–23 was nearly double that in the corresponding season of 1923–24; this variation is attributed to differences in the relative amounts of bituminous coal and anthracite consumed in the city.

A series of observations were obtained from aeroplanes, a dust counter of five times larger capacity than standard being employed; this was equipped with ten interchangeable heads, in which cover glasses were placed before the flight. The records indicated a marked falling off in the number of particles above a certain height—approximately 6000 ft. in August and 3000 ft. in October and November. The amount of impurity present is less after a storm of rain, and in clear weather the dust content may increase between the surface and 2000–5000 ft.; this may be due to convection, and in such weather the visibility at a height of several thousand feet may be much worse than at the surface. A. W. L.

**2449.** *Measurements of Solar Radiation and Atmospheric Turbidity over the Atlantic Ocean and in Argentina.* **F. Linke.** (Monthly Weather Rev. 52. pp. 157–160, March, 1924.)—Values of the intensity of radiation, turbidity factor, absolute humidity, and blueness of the sky have been obtained from observations taken on an expedition which left Hamburg for Argentina on April 5, 1923, and returned to Hamburg on August 15, 1923. The turbidity is divided into two parts, the former being due to the absorption by water-vapour and the latter to reflection from solid particles in the atmosphere. The percentage of red radiation transmitted appears to be practically independent of the dry turbidity and directly proportional to the vapour pressure. From this the effect on the red radiation of the selective absorption by water-vapour may be determined. The diurnal variation of the turbidity factor shows a maximum about mid-day and a decrease towards evening. The mid-day maximum may be caused by the increase in the relative humidity at the upper limit of the convective layer. A. W. L.

**2450.** *The Crepuscular Phenomena of Mont Blanc.* **E. Bauer, A. Danjon and J. Langevin.** (Comptes Rendus, 178. pp. 2115–2117, June 16, 1924.)—The crepuscular phenomena observed at a station at a considerable altitude have been studied at the Vallot Observatory (4347 m.). The purple arch resting on the earth shadow was observed, but the primary crepuscular arch and the purple glow were not seen. The secondary crepuscular arch was observed frequently, and the heights of the colours which correspond with different distances of the sun below the horizon have been obtained. When the sun reaches 17° 50′ below the horizon the arch disappears, but at 21° a further faintly luminous segment has been observed; this may be another crepuscular arch. The results obtained are in accordance with the view that the arches are caused by the scattering of sunlight in the atmosphere around the earth shadow. A. W. L.

**2451.** *Organic Bodies Found in the Air of Washington and London.* **N. Shaw.** (Monthly Weather Rev. 52. pp. 139–141, March, 1924.)—Comparatively large particles, which appear to be of organic origin, have been found in records of atmospheric pollution both in England and America. These particles are generally oval in shape, and occur in greater numbers in wet weather, when there may be over 20 per litre. As far as can be observed, the bodies correspond with spores of mildew; they may be explained on the basis of spores of microfungi which occur more frequently in wet weather. The cells occurring on dead leaves appear to be identical with, and are probably the chief cause of, those occurring in the atmosphere. A. W. L.

**2452.** *Magnetic Method of Geological Exploration.* **W. O. Hotchkiss.** (Am. Inst. Mining Eng., Trans. 69. pp. 36–47, 1923.)—In view of present-day high working costs for mining, magnetic methods of surveying where rocks are obscured by soil are recommended, since field methods are capable of detecting small variations in magnetite content. The factors influencing the magnetic effect of magnetite are discussed, *viz.* the amount of magnetite, its permeability, and the shape and disposition of the magnetic mass. In rocks the amount of magnetite may vary from zero to over 9 per cent. The use of the declination compass and the dip needle with counterpoise is described. In the author's form of the latter instrument the axis of the needle is perpendicular to the line of total force, and the counterpoise acts at the end of a horizontal arm. If the total force changes, the needle becomes unstable, and a large deflection results. By changing the inclination of the arm to the axis of the needle the sensitiveness of the needle may be varied. When the magnetic method was applied in the work of the Wisconsin Geological Survey, the boundary between a quartzite and a slate could be followed with assurance, even though covered by many feet of glacial drift. Other instances are related in which the method was successful in elucidating geological structure. G. E. A.

**2453.** *Seismophysics and the Interior of the Earth.* **R. Yamamoto.** (Ann. de Physique, 1. pp. 293–345, May–June, 1924.)—A comprehensive exposition, mostly mathematical, of the theory applying to the propagation of seismic waves. The general theory of the waves is given as well as the methods used for calculating the positions of the epicentre and the hypocentre and the velocity of the waves. The general correctness of the theory is tested by applying it to the case of the Japanese earthquake of September 1, 1923. Hence the velocity of the longitudinal wave at the surface is 7·205 km. per sec., which compares well with the value 7·174 given by Zöppriz and Geiger. The theory of Wiechert that the centre of the earth is of metallic iron appears to lack confirmation, as the variation of velocity with depth appears to be continuous. A. Wh.

## ASTRO-PHYSICS.

**2454.** *Rotation Period of the Sun as Derived from Magnetic Storms.* **E. W. Maunder** and **A. S. D. Maunder.** (Roy. Astron. Soc., M.N. 84. pp. 610–615, June, 1924.)—The number of well-defined magnetic storm pairs is tabulated against the time interval between the components of the pair, and a sharp maximum is apparent at 27–27·2 days. Hence it is concluded that the mean rotation period as derived from magnetic storms is sensibly the same as that given by spots, faculæ and similar phenomena. The conclusion is drawn that the streams of electrons behave as if they were rotating with a similar velocity to the areas from which they originate. Photographs of prominences support this interpretation, and an analysis of certain nebular phenomena by Jeans shows that such a form of motion is to be expected under some circumstances. A. Wh.

**2455.** *Photometric Intensity of Corona at Eclipse of* 1922, *Sept.* 21, *at Wallal.* **A. D. Ross.** (Roy. Astron. Soc., M.N. 84. pp. 660–662, June, 1924.)—A description is given of the photometer and means whereby the light intensity from three sources could be recorded in each test on the same plate. Two forms of plate were used—an Ilford Special Rapid and a Wellington Antiscreen—and exposures were made on the moonlight of Sept. 6 and the coronal light of Sept. 21 at the same altitudes. The first plate gave for the coronal light as compared with moonlight the values 0·62 and 0·59, the second 0·77; the difference being attributed to the difference in sensitiveness in the plates to the green. The author suggests that coronal light differs from time to time in the ratio of visual to actinic rays and in its whole intensity, and probably this variation progresses with the solar cycle. An amylacetate lamp test gave 0·18 lux for the brightness of moonlight on Sept. 6. A. S. D. M.

**2456.** *Diameter of Sun.* **G. Armellini.** (Accad. Lincei, Atti, 33. i. pp. 330–334, May 4, 1924.)—The mean diameter of the sun at the mean distance is, including irradiation, 16′ 1″·40 ± 0″·02, to compare with the conventional 16′ 1″·18. The probable error, ± 0″·02, is much less than the presumable pulsation of the solar diameter (not exceeding 1″, Lane, Ambronn, Schur). A. D.

**2457.** *Cosmical Refraction.* **H. Kienle.** (Phys. Zeits. 25. pp. 306–307, June 15, 1924.)—In reply to L. Courvoisier [Abstract 1107 (1924)], Kienle maintains that it was necessary to warn readers against accepting conclusions which are based on a mistaken method. This method he demonstrates by two figures, representing graphically Courvoisier's reduction of observations of two stars. In each figure three lines are drawn, one connecting points which indicate the actual observations, one representing the interpolation curve of Courvoisier based on these observations, and one his theoretical curve of yearly refraction. It is pointed out that the observational and the theoretical curves have scarcely any resemblance to one another. M. A. E.

**2458.** *The Orrery in the Deutsches Museum, Munich.* **W. Bauersfeld.** (Zeits. Vereines Deutsch. Ing. 68. pp. 793–797, Aug. 2, 1924.)—This article describes the construction of an orrery which has been designed and made by the firm of Zeiss in Jena. By means of a projection apparatus a graphical representation is given on a sphere, 10 m. in diam., of the apparent motions of the heavenly bodies, including the sun, moon, planets and the fixed stars. W. H. S.

**2459.** *Real and Apparent Velocities.* **A. V. Douglas.** (Roy. Astron. Soc., M.N. 84. pp. 491–493, May, 1924.)—Adams' and Eddington's results concerning the relations between velocities and absolute magnitudes of giant stars are criticised in the light of Silberstein's work [Abstract 1112 (1924)] on de Sitter's space-time theory. It is shown that, although for stars comparatively near to the observer the spectral displacement depends chiefly upon their actual radial velocity, for stars at distances beyond 100 parsecs it depends chiefly upon the curvature invariant of space-time. Hence velocities too high have probably been ascribed to the very remote stars included in these investigations, and these stars must also be intrinsically very bright. It is possible that if this error were corrected, the progression of radial velocity with absolute magnitude would agree better with Eddington's formula for tangential velocity. M. A. E.

**2460.** *Measures of Double Stars discovered since 1905 made at the Lille Observatory and at the Royal Observatory, Greenwich.* **R. Jonckheere.** (Astron. J. 35. pp. 173–180, June 30, 1924.)

**2461.** *Mean Absolute Magnitude of a Group of Stars.* **G. Prasad.** (Roy. Astron. Soc., M.N. 84. pp. 493–499, May, 1924.)—Absolute magnitudes and parallaxes, together with the methods employed in finding them, for stars of types F to M have been published by the Mt. Wilson, the Norman Lockyer, and the Dominion Astrophysical Observatories, and the method employed at the latter differs from the others. This method is criticised, and objections to the formulæ used are pointed out. None of the objections apply to the formula used by Edwards at the Norman Lockyer Observatory for his work on the B-type stars [Abstract 1736 (1924)]. M. A. E.

**2462.** *Absorption of Radiation within a Star.* **S. Rosseland.** (Roy. Astron. Soc., M.N. 84. pp. 525–528, May, 1924.)—Eddington [Abstract 893 (1917)] has given the mean absorption coefficient in the interior of a star as :—

$$X = \frac{\int_0^\infty B(\nu) X_\nu d\nu}{\int_0^\infty B(\nu) d\nu}.$$

where $B(v)$ is the energy of black body radiation of energy $v$ and $X_v$ the absorption coefficient for this frequency. This coefficient can only validly be used when $X_v$ is independent of the frequency. From the fundamental equation of radiative transfer it is concluded that $X$ should be defined by :—

$$\frac{1}{X}=\frac{\int_0^\infty \frac{\partial B(v)}{\partial T}\frac{dv}{X_v}}{\int_0^\infty \frac{\partial B}{\partial T}dv}$$

Averaging the absorption coefficient according to this expression will intensify the discrepancies between theory and observation already noted by Eddington. A. Wh.

**2463.** *Cumulative Ionisation in Stellar Atmospheres.* **M. C. Johnson.** (Roy. Astron. Soc., M.N. 84. pp. 516–524, March, 1924.)—The effect is considered of taking into account the flux of radiation from the interior of a star upon the equilibrium ionisation of the external layers. Such radiation, by exciting atoms, will render some electron collisions potent to effect ionisation which would not otherwise have done so. In general the probability of ionisation in the stellar atmosphere will be increased if the effect of radiation is taken into account. Cumulative ionisation may also explain the greater ionisation of barium than sodium in the sun, as the former has three excitation potentials before ionisation at 5·19 volts, while the latter has two and ionises at 5·11 volts. The time taken for the return of an electron in an excited or ionised atom seems to be greater for ionised than for excited atoms. This may explain the rapidity of successive ionisations noted by Saha. A. Wh.

**2464.** *Jeans' Theory of Origin of Stars.* **H. Shapley.** (Harvard Coll. Obs. Circ. 257. [4 pp.], 1924.)—A critical investigation of Jeans' argument that the sun was a condensation of the arm of a spiral nebula of density enormously lower than it is now, and of size correspondingly greater [see Abstract 1102 (1924)]. The example investigated is Messier 33, whose parallax is accepted as 0″·0005, and at this distance typical low-density giant stars of all classes would be brighter than the 12th apparent magnitude. The nebulous points measured (supposed by Jeans to be ancestors of stars) in Messier 33 have a photographic magnitude of about eighteen, and the corresponding absolute magnitude can be only + 6 or fainter, indicating a luminosity like that of dwarf K-stars. Within 4 degrees of Messier 33 are 500 faint irregular nebulous flecks, quite non-stellar in appearance, and probably past products of the nebula; if they are at its distance they are intrinsically very faint, and the distribution of faint stars in the region shows no influence of the great spiral. Similarly for other bright nebulæ, photometric examination shows that spiral nebulæ are not directly generating either stellar clusters or typical stars that are larger and less dense than the sun. A special case is given of contrasted distribution of giant stars and spirals—in the north galactic hemisphere a conspicuous group of bright nebulæ, in which sphericals, ellipticals, spirals and spindles are closely associated, evidencing genetic relationship. Of these, the integrated photographic magnitudes have been measured, and they show relatively small dispersion in their magnitudes, the average being about one fainter than that of van Maanen's spirals, so that probably they are less than twice as distant, and any stellar bodies produced from them should be about a magnitude fainter than those produced by van Maanen's spirals. But the relative frequencies of stars in this region show no youthful stars nor unusual numbers of stars, but rather a deficit. If the nebulæ are traced backward along their hypothetical paths in space, no evidence is found of past stellar creations from these spirals, nor any transition from faint non-galactic nebulous fleck to highly luminous galactic class M giant star. The direct data of photometry and stellar distribution lend little support to the hypothesis that spiral nebulæ are generating normal low-density stars. A. S. D. M.

**2465.** *Distance and Dimensions of the Smaller Magellanic Cloud.* **H. Shapley.** (Harvard Coll. Obs. Circ. 255. [5 pp.], 1924.) The methods used in revising the photographic magnitudes of stars in the Small Cloud are described, and the parallaxes of 89 Cepheid variables contained in it are found by deduction from the period-luminosity curves of these stars. The weighted mean of these parallaxes gives a distance of 31 kiloparsecs for the Small Cloud and a linear diameter of 2 kiloparsecs, equal to 6500 light-years. Its velocity of recession is about 170 kilometres per second, and if this has been essentially the same in the past the Cloud must have been in or near the plane of the Milky Way in the year $-1\cdot9 \times 10^8$. This suggests the possibility that the star-clouds now in the Milky Way may not remain permanently as a part of our system. The brightest stars in the Small Cloud appear to have a higher luminosity than any yet recorded, being more than 50,000 times as luminous as the sun. Some of the brightest variables have been shown to belong to classes K5 and M, and if the usual relation of surface luminosity and spectrum which obtains in the Galaxy applies also to these stars, they must have diameters of the order of $10^9$ kil., being therefore much larger than Betelgeuze and Antares. Other points will be dealt with in later papers. M. A. E.

**2466.** *Spectroscopic and Magnitude Observations of Mira Ceti*, 1924. **W. J. S. Lockyer.** (Roy. Astron. Soc., M.N. 84. pp. 558–568, June, 1924.)—The observed date of maximum was Jan. 29, 1924, as predicted by Leon Campbell, and the observed brightness was magnitude 4·9, the faintest maximum recorded since 1886. Since greater divergencies occur in estimating the brightness near the time of maximum than occur at other times, even amounting sometimes to a whole magnitude, it seems possible that Mira at maximum undergoes rapid oscillations. Two series of spectra were obtained, one with the 12-inch and the other with the 9-inch prismatic camera, and altogether thirteen photographs were secured between Jan. 4 and Feb. 23, 1924. An examination of these, and a comparison with photographs taken by various observers at other maxima, show that the relative brightness of the hydrogen lines at maximum is the same, however the maximum brightness of the star may differ. The presence of other bright lines, which has been suspected, is regarded as disproved, as apparent bright lines were identified with interspaces between absorption lines, especially when the spectrum of Mira was compared with that of α Herculis; for the spectrum of this star, which is of type Md, without any bright lines, has dark lines and bright interspaces identical with those of Mira, and the intensities in both spectra are also remarkably similar. The chief absorption lines in Mira are due to the elements usually recorded, namely Ca, Fe, Al, Sr, Cr, V; and Mn and Ti, about which some observers had expressed uncertainty, were found to be undoubtedly present also. All the flutings of titanium oxide tabulated by Fowler, which fell within the range of the plates used, are recorded. Two illustrations accompany this paper, showing the spectra obtained, one with other stellar spectra for comparison, and the other demonstrating the identification of the absorption lines with the elements above mentioned. M. A. E.

**2467.** *Absorption Bands in Celestial Spectra.* **F. E. Baxandall.** (Roy. Astron. Soc., M.N. 84. pp. 568–575, June, 1924.)—The G type of stellar spectra (to which the sun belongs) is the earliest type to show bands or flutings as well as lines, but later types all have banded spectra of some form or other. R- and N-types show strong carbon absorption, K and M strong $TiO_2$ absorption, and the class S, recently added by Merrill, shows all the thirteen bands of zirconium oxide. In some of these types there are also prominent bands which have not yet been identified. Sunspot spectra have marked banded absorption, the three most prominent elements represented being titanium oxide, magnesium hydride and calcium hydride, but there are also many other local regions of absorption which strongly suggest heads of bands. In this paper the author has brought together and catalogued in order of wave-length all the apparent bands whose positions in stellar and solar spectra have been recorded or are recognisable from published reproductions, the total number of bands amounting to 112. The chief sources used for this purpose are Roland's maps of the Fraunhofer spectrum; Hale's sunspot maps; Stebbins' spectra of Mira and other M-type stars; Rufus' spectra of R stars; Hale, Ellerman, and Parkhurst's N stars; Merrill and Wright's S stars. The writer has used his own discretion as to what he judges to be heads of bands in the sunspot spectra. Bands hitherto unidentified have been compared with the bands of various chemical compounds, but there appears to be little evidence for the identification of the great majority with any other substance than those already known in stellar spectra, namely compounds of carbon, titanium, magnesium, calcium, and zirconium, with oxygen, hydrogen, or nitrogen. M. A. E.

**2468.** *Spectrum of γ Cassiopeiæ, Hβ to B.* **Stonyhurst College Observatory.** (Roy. Astron. Soc., M.N. 84. pp. 576–582, June, 1924.)—This paper summarises the spectroscopic investigation of γ Cassiopeiæ carried out in 1921–22, and completes the work of Father Sidgreaves on the star, which he published in 1890 (M.N., R.A.S., 50, 505). His study of wave-lengths extended from λ3963 to λ5576, and the present study extends from Hβ to B, thus giving a sufficient overlap for comparison. Out of about twenty photographs secured, the best six were selected for measurement, and three micrometer settings were made on each line, both in the direct and in the reverse positions. Table I gives the intensities, character (emission or absorption), and probable origins of the lines, as well as their wave-lengths; and also the measurements of Dr. Curtiss, Father Sidgreaves (where there is overlap), and Miss Heger (Lick Observatory) for comparison. There is no indication of variability in the spectrum so far as the prominent lines of hydrogen and the faint bright line D3 are concerned; and where different observers have assigned different characters to the same lines it is most likely that the lines have both emission and absorption components. The predominant feature of the spectrum is the series of bright hydrogen lines, decreasing in intensity with decrease in wave-length. The bright lines H$\alpha$ and H$\beta$ are very broad, and are probably double lines, unresolved on account of the smallness of the dispersion (the length of the spectrum from H$\beta$ to B is a little less than 8 mm.). Otherwise the spectrum consists mainly of bright lines of no great intensity, interspersed with dark bands. In this portion of the spectrum the bright lines are much more numerous, and they are practically all identical with lines in the sun's chromosphere. The plate which accompanies the paper shows the complete spectrum of the star in three overlapping sections. M. A. E.

**2469.** *Radial Velocities of Stars of Spectral Class R.* **R. F. Sanford.** (Mt. Wilson Observat. Contrib. No. 276. Astrophys. J. 59. pp. 339–355, June, 1924.)—The most marked features of the spectra of R-type stars are bands, due to carbon and its compounds, resembling those of N-type stars; but there are differences in individual lines and in relative line-intensities, and R stars have more light in the violet, especially among the early sub-types. The Harvard observers have found between 60 and 70 stars of this class scattered over the sky, all of which are invisible to the naked eye, and 61 % of visual magnitude 9 or fainter; they are all red, and therefore fainter photographically than visually. Rufus has made a careful study of the spectra of 10, and deduced their radial velocities (Publications of the Observatory, University of Michigan, 103, 1916). Since the year 1919 efforts have been made at Mt. Wilson to obtain spectrograms of as many stars of this class as possible with the 100-inch telescope, using a slit-width of about 0·002 inch and a dispersion usually of 44 A per mm. at λ4500; and a table is now given showing the radial velocities of 29 R stars (including the 10 of Rufus), with the addition of one S star and one peculiar variable somewhat resembling N stars.

Comparison of the radial velocities of R and N stars furnishes further justification for certain systematic corrections which Moore applied to his velocities for N stars, and connects the radial-velocity systems of classes R and N in a satisfactory manner. Although the data are limited, the solar motion referred to this group of R stars seems to be in satisfactory agreement with that derived from stars in general, and thus confirms the measures. There are no trigonometrical parallaxes for any of these stars, and the proper motions are all very small, but an approximation to the mean parallax for 18 of them has been obtained by combining parallactic and peculiar motions with radial velocities, and from this a mean absolute magnitude of $-1 \cdot 5$ has been deduced, which agrees so closely with Moore's value for N stars that the two classes must be nearly alike in luminosity. The varying relative intensities of a pair of spectral lines have been studied, and found to agree in behaviour with the same pair in giant G stars. Thus confirmation is found for the spectral sequence of G, R, N stars already established on other grounds.

Spectrograms of R and N stars taken with ammoniated Ilford Special Rapid Panchromatic plates indicate that these red-sensitive plates could be used with advantage for late R and Nb stars. M. A. E.

## LIGHT.

**2470.** *The Velocity of Light.* **M. la Rosa.** (N. Cimento, 1. pp. 49–98, Jan.–April, 1924.)—The author discusses the question as to what would be seen if a more or less remote double star emitted light with a velocity $V = C + v$ or with a velocity $V = c$. The facts predicted on the former hypothesis, not on the latter, are in accordance with observation. This tells against Einstein's postulate of the constancy of the velocity of light, $V = c$. The superstructure erected by Einstein on the foundation of relativity will have to be rebuilt, as it can be, on the ballistic hypothesis $V = c + v$. All the facts so far observed are in harmony with the ballistic hypothesis. There are, however, some outstanding difficulties, as to which a further paper is promised. A. D.

**2471.** *Metallic Lustre. I.* **W. D. Bancroft and R. P. Allen.** (J. Phys. Chem. 28. pp. 588–610, June, 1924.)—In continuation of previous work [Abstract 1031 (1919)], the author discusses critically the subject of metallic lustre from the point of view of the psychologists, contributions to the subject made by Wundt, Dove and Kirschmann being examined in detail. Wundt maintains that lustre is observed when one sees or thinks one sees one image behind another. Kirschmann's theory is based on Wundt's, and leads to the conclusion that metallic lustre is due to the parallax of indirect vision. The author considers that a very considerable portion of the theory developed by Kirschmann is incorrect. J. S. G. T.

**2472.** *Critical Opalescence.* **A. Andant.** (Ann. de Physique, 1. pp. 346–420, May–June, 1924.)—Critical opalescence is the term applied to the phenomena observed in the neighbourhood of the critical point of a substance. The most important of these phenomena is the diffusion of light which accompanies the disappearance and reappearance of the interface or meniscus separating the liquid and gas phases. The author reviews briefly previous theoretical and experimental work on this subject, and gives details of an experimental investigation of the critical opalescence observed in the case of ethyl ether and a series of four homologous acetic ethers. The results obtained indicate that from the temperature at which opalescence appears to within 0·15° of the critical temperature the opalescence is inversely proportional to the difference between the critical temperature and the temperature at which the observation is made. The liquid phase is slightly more opalescent than the vapour phase. Over the same range of temperatures the opalescence varies as $\lambda^{-4}$, $\lambda$ denoting the wave-length of the diffused light. In the immediate neighbourhood of the critical temperature, the exponent of $\lambda$ in the expansion indicating the relation between the opalescence and wave-length passes continuously from the value $-4$ to $-2$. The opalescence observed was found to be expressible as a parabolic function of the content of the tube employed. The temperatures of disappearance of the meniscus and its reappearance were similarly expressible as parabolic functions. For a certain critical content the temperature at which maximum opalescence was observed corresponded with either of these temperatures or with the critical temperature indifferently. In the case of the series of homologous acetic ethers studied the opalescence varied approximately as the square of the molecular weight of the ether. These results are in agreement with the theory developed by Einstein and Smoluchowski and extended by Ornstein-Zernicke. Values of Avogadro's constant equal to $58 \times 10^{22}$ and $62 \times 10^{22}$ were deduced by applying the Einstein-Smoluchowski formula to observations of the opalescence observed in the case of ethyl ether at a temperature 1·2° below the critical temperature. [See also Abstract 1350 (1923).] J. S. G. T.

**2473.** *Critical Opalescence of Carbon Dioxide.* **D. K. Bhattacharyya.** (Indian Assoc. for Cultivation of Science, Proc. 8. 4. pp. 277–288, 1923.)—Raman and Ramanathan have investigated the scattering of light in $CO_2$ over a wide range of temperature and pressure [Abstracts 892, 893 (1923)], and the results obtained conform with the theory as proposed by Einstein and Smoluchowski. The experimental arrangement, however, did not admit of exact determinations in the immediate neighbourhood of the critical temperature where the Einstein expression for the fraction scattered would become infinite. Ornstein and Zernicke have modified the formula to suit the case of the critical temperature. This modified formula reduces to

$$\alpha = (\pi^2 RT\beta/18N\lambda^4) \,.\, (\mu^2 - 1)^2 \,.\, (\mu^2 + 2)^2 \quad \ldots\ldots\ldots \quad (1)$$

where $\alpha$ is the fraction of light scattered per unit volume per unit solid angle in a direction perpendicular to the incident beam, $\beta$ is the compressibility, R is the gas constant, T the absolute temperature, N the Avogadro number, $\mu$ the refractive index, and $\lambda$ the wave-length. For the critical temperature

$$\alpha_c = \tfrac{1}{72} v(\mu^2 - 1)^2(\mu^2 + 2)^2\mu^2/N\epsilon^2\lambda^2 \quad \ldots\ldots\ldots\ldots \quad (2)$$

$v$ is the molecular volume and $\epsilon$ the radius of action of a single molecule.

In the author's experiments the $CO_2$ was contained in a sealed glass bulb placed at the centre of a thermostat, the temperature of which could be varied between 29° and 35° C. and read to 0·01° by means of a Beckmann thermometer. Light from a pointolite lamp of 1000 c.p. passed through the liquid, and the light scattered normally was examined by a Hilger spectrometer. Comparison of intensity was made with the direct light from the lamp, which passed through two Nicols. The relative orientation of the Nicols allowed of adjustment of equality of intensity of the two halves of the bands in the spectrometer. Curves given in the paper show that for temperatures some distance above and below the critical temperature $\alpha$ varies inversely as $\lambda^4$, but in the immediate neighbourhood of the critical temperature inversely as $\lambda^2$. It was also found that the intensity for a fixed wave-length is greater with falling temperature than with rising temperature. This has been previously noticed by Andant [Abstract 2272 (1922)]. By using a perforated disc rotated at a known speed the intensity of the opalescence was determined absolutely. This direct determination at 30·5° C. and for $\lambda = 5400$ Å. gave $\alpha = 2{\cdot}79 \times 10^{-4}$. The value calculated from equation (1) is $2{\cdot}26 \times 10^{-4}$. A mean value of $\alpha_c$ reduced from the relative intensity curves is $9{\cdot}76 \times 10^{-4}$, which gives for $\epsilon$ by equation (2) $7{\cdot}7 \times 10^{-7}$ cm. L. L.

**2474.** *Dispersion of Water in the Ultra-violet.* **J. Duclaux** and **P. Jeantet.** (J. de Physique et le Radium, 5. pp. 92–94, March, 1924.)—

In continuance of experiments previously described [see Abstract 856 (1922)], the refractive index of water at 20° C., with reference to air for a further range of wave-lengths obtained by sparking between electrodes of Al, Cd, Zn and Ag, is determined with great precision in an apparatus of which the optical and geometrical constants are calibrated by the determination of the accurately known refractive indices for the rays D and H. A table is given showing the results obtained, together with the corresponding indices calculated from the ordinary dispersion formula and some results obtained by Flatow. Curves are also given indicating variation of refractive index with wave-length for water, fluorine, and quartz, from which it is seen that the dispersion of water, feeble in the visible spectrum, becomes, in the ultra-violet, considerable and superior even to that of quartz. A. B. C. L.

**2475.** *Theory of Diffraction at Edge of a Black Screen.* **A. Rubinowicz.** (Ann. d. Physik, 74. 5. pp. 459–460, June, 1924.)—Claims priority in the treatment of Kirchhoff's theory described by F. Kottler [see Abstract 2398 (1923)]. J. W. T. W.

**2476.** *The Law of the Limiting Perception of Luminous Flashing Signals.* **A. Blondel** and **J. Rey.** (Comptes Rendus, 178. pp. 1245–1247, April 7, 1924.)—Referring to the paper of H. Piéron [Abstract 1421 (1924)] the authors point out that he has been studying a different phenomenon from that which they have been investigating. The controversy between them appears to be largely one of terminology. What Piéron calls "luminous excitation of the retina by brief flashes" should strictly be called excitation by "brief illuminations." The law established by the authors is intended solely to apply to the best conditions of emission of signals from lighthouses or of similar signals produced by sources which, as they are to be observed at great distances, behave for the observer as if coming from point sources. As Piéron has remarked, the point sources of light investigated by the authors can excite only a single cone or a single rod, and have thus a special character physiologically. Piéron has studied trains of luminous waves of finite dimensions, and has seen opposition between his results and those of the authors. In reality the two phenomena have nothing in common. The different sets of experiments deal with quite different facts. By employing large numbers of inexperienced observers preconceived prejudice is avoided, and the method of recording avoids errors due to auto-suggestion. The observations of the authors are meant to apply to *maritime* signals, in which it is impossible to realise signals of duration less than $\frac{1}{50}$ sec. J. J. S.

**2477.** *Effect of Colour of Light on Visual Fatigue.* **O. Schneider.** (Zeits. techn. Physik, 5. 8. pp. 355–357, 1924.)—The author describes the results of reading tests carried out to determine the relative fatigue of the eye with twenty lux illumination of lights of various colours. The results obtained with yellow light were similar to those obtained with white (tungsten filament vacuum lamp). Maximum fatigue was found with red and with blue-green lights. J. W. T. W.

**2478.** *Effect of Composition of Light on Important Ocular Functions.* **C. E. Ferree** and **G. Rand.** (Am. Illum. Eng. Soc., Trans. 19. pp. 424–

447; Disc., 447–455, May, 1924.)—In investigations of the eye's acuity, speed of discrimination, and power to sustain acuity for spectrum lights of a high degree of purity, the efficiency of the eye is found to be greater in the mid-region of the spectrum, but is still inferior to that obtained with white light illumination. The spectrum lights employed in the investigation are equalised both as to saturation and luminosity. Fatigue tests are carried out showing that yellow (amber) light is most favourable for sustaining clear sight, and shows the least tendency to produce discomfort. In the *Discussion*, the ocular values of various "daylight lamps" are referred to, and a short account is given of the physiological and pathological effects of working under conditions of low-intensity illumination. A. B. C. L.

**2479.** *The Rotation of the Plane of Polarisation of Light in Liquids by a Magnetic Field.* **M. Sende** and **G. Wiarda.** (Phys. Zeits. 25. pp. 278–280, June 1, 1924.)—Experiments are described which lead the authors to the conclusion that the phenomena observed by Marshall Holmes are of a subjective nature. [See Abstract 68 (1924).] J. J. S.

**2480.** *Projection of Phototypes of Large Size over Great Distances.* **L. Lumière.** (Rev. d'Optique, 3. pp. 281–283, June, 1924.)—The projection of large images in a room where the screen is necessarily far from the objective presents special difficulties with images obtained on autochrome plates on account of diffusion. A satisfactory solution of the problem is furnished by the use of objectives made up of two planoconvex lenses, associated as in Ramsden's ocular. A. B. C. L.

**2481.** *The Application of the Tube Photometer in Spectrophotometry.* **K. Schaum, W. Henss.** (Zeits. wiss. Phot. 23. pp. 7–11, June, 1924.)—The weakening of light by means of diffuse reflecting colourless layers, as it has been applied by K. Schaum and S. Selig to quantitative spectral photography, meets with difficulties in the ultra-violet, since the enfeeblement of light obtained by means of photometric measurement in the visible portion does not hold for the region of selective absorption. The authors have therefore endeavoured to make use of the quite simple light weakening by diffusion in such a way that it may be also available for the region of selective absorption. The two bundles of rays are compared by means of a so-called "tube photometer," and the weakening of the light is produced, not by increasing the diffusing layers, but by lessening of the scattering surface in which a path of radiation is caused. Details are given of the arrangement and the results obtained in the case of potassium bichromate. The authors hope shortly to make the apparatus in quartz and carry out measurements in the ultra-violet. J. J. S.

**2482.** *Double Spectrograph for the Far Ultra-Violet.* **P. Lambert, G. Déjardin** and **D. Chalonge.** (Rev. d'Optique, 3. pp. 277–280, June, 1924.)—The instrument was designed for the study of solar radiation of wave-length 2100 Å. Less refrangible rays are diffused by the optical elements of an ordinary spectrograph in such quantity as to fog the plate before the shorter waves can be recorded. In place, therefore, of an instrument with 60° prism two spectrographs are used in train, each having a 30° quartz prism and lenses of 15·5 cm. focal length (for 2000 Å.). The spectrum from the first is thrown on to a screen with adjustable shutters, which are arranged to transmit only that part of the spectrum which it is intended to photograph with the second instrument. Most of the copper lines between 2150 Å. and 1950 Å. were recorded with an exposure of one second. Both ordinary plates, treated with fluorescent oil, and also Schumann plates were used. With the latter no trace of solar radiation in this region was recorded in forty minutes. F. S.

**2483.** *The Relation between Aperture, Axial Thickness and Form for a Single Lens.* **T. Smith.** (Optical Soc., Trans. 25. 3. pp. 107–112; Disc., 112, 1923–1924.)—The paper contains a comparison between the exact and various approximate expressions connecting the attainable aperture and the axial thickness for simple lenses of various shapes. The most accurate formula suggested is

$$T \triangleq A\{1 - 2A(X + 3)\}/\{1 - 5A(X + 2)\}$$

where A, T and X are ratios depending respectively on the aperture, thickness and lens shape in relation to total lens curvature. The paper itself should be consulted, as it is entirely mathematical. In the *Discussion* the above formula was welcomed, present practice using a form $T \triangleq A + A^2(3x^2 + 1)/3 = A(1 + A/3) + A^2x^2$, where $x = (R_1 + R_2)$, $T/(R_1 - R_2)$, $R_1$ and $R_2$ being the curvatures of the two surfaces.

H. H. Ho.

**2484.** *On Lens Faults for Oblique Pencils.* **Eva Haberland.** (Zeits. f. Physik, 24. 5–6. pp. 285–323, 1924.)—The paper contains an extension of the Waetzmann-Bratke interference method [see Abstracts 473 and 1144 (1924)] for the investigation of optical systems to the case of oblique pencils. The interference images are investigated for different types of objectives with inclined lenses. The characteristic forms of the interference curves of the normal case are found to be unsymmetrically distorted. For objectives, which in the normal position exhibit perpendicular equidistant fringes by which the spherical aberration for axial points is corrected, the interference curves are now bent and the curve distances increase from the edge image. The theory of interference for oblique pencils is developed first for a theoretically perfect case, and then for practical examples, using as far as possible general assumptions as to lens errors. The theory is then applied to the special case where the only lens error is the curving of the focal surface, a circumstance which for some telescope objectives has been supported by observations. Comparison with experimental results showed that valid conclusions may be drawn with respect to lens faults (distorted image, astigmatism, coma, etc.) from the interference images, and quantitative agreement with theory was found by curvature determination of the image. The author opines this line of activity will yield fruitful results in this field if pursued. A process is described for the determination of focal distances for oblique pencils. Some twenty-four figures and photographs are included in the paper, which is mainly mathematical. H. H. Ho.

**2485.** *Use of "Diametral Plane" in Elementary Geometrical Optics.* **C. H. Lees.** (Phys. Soc., Proc. 36. pp. 294–299; Disc., 299–302, June, 1924.)—Shows that if a lens be specified, not by its focal length when in air, but by its two radii of curvature and its refractive index (or the velocity of light within it), the graphical method can be used to solve quite simply such problems as the relative sizes of object and image. In the *discussion*, **T. H. Blakesley** and **R. Appleyard** suggested other ways in which departures might advantageously be made from the classical methods of teaching geometrical optics. J. W. T. W.

**2486.** *Anomalous Dispersion in the Vapours of Alkaline Metals.* **F. Rasetti.** (N. Cimento, 1. pp. 115–131, Jan.–April, 1924.)—Experimental investigation on the ratios of the coefficients in Sellmeier's formula as between the two rays of various doublets in the principal series of line-spectra of the alkaline metals. The Sellmeier formula must now be regarded as an empirical approximation, departed from at distances small in comparison with the wave-length. A. D.

**2487.** *Scattering of Light.* **A. Carrelli.** (Accad. Lincei, Atti, 33. i. pp. 279–282, April 13, 1924.)—When a beam of plane polarised light is passed through a suspension of small particles, the scattered light is diffused in a direction normal to the electric vector in the incident beam. This light is polarised. With greater concentration and increasing grain size it is found that light is emitted in other directions, in which the wave-length distribution involves the eighth instead of the fourth power. This would be due to secondary scattering. A. Wh.

**2488.** *Electromagnetic Theory of the Scattering of Light in Fluids.* **K. R. Ramanathan.** (Indian Assoc. for Cultivation of Science, Proc. 8. 3. pp. 181–198, 1923.)—The author corrects and extends his former paper on this subject. The reported change in the imperfection of polarisation of the transversely scattered light in carbon disulphide when the wave-length of the incident light is altered is not confirmed. Other liquids examined also do not show this effect. The results recently obtained by Cabannes and King, and their theories of molecular scattering of light in fluids are discussed. The conclusion is reached that the presence of loose molecular groupings having a higher degree of symmetry than the individual molecule would explain the observed low value of the imperfection of polarisation of the scattered light in many liquids. J. J. S.

**2489.** *On Some Properties of Photographic Plates.* **C. Fabry** and **H. Buisson.** (J. de Physique et le Radium, 5. pp. 97–104, April, 1924.)—The authors have obtained some new results with an instrument for registering the densities of photographic plates during a long series of researches on the radiation of solar ultra-violet rays and atmospheric absorption. The laws of darkening of plates are discussed in the light of Hurter and Driffield's results, and it is pointed out that for normal development the value of gamma ($\gamma$) is unity, but for prolonged development $\gamma$ may be of 2 and 3. The influence of the wave-length of the active radiation on the development curve is considered, and a curve is given showing the variation of $\gamma$ from about unity value for a wave-length of 2500 to 3000, with a gradual increase to nearly 3 for wave-lengths of 4000 to 4500. Photo-micrographs of sections of photographic plate films are given showing the differences in the constitutions of the emulsions with the visible and the ultra-violet radiations. Calculations are given in connection with the density and exposure relation, the results leading to a final expression for the density D of the form $D = C + (m'/m) \log I$, where I is the intensity of the radiation received and $m'/m = \gamma$, $c$ being a constant [see also Abstract 1766 (1924)]. A. W. J.

**2490.** *Diffusing Power of Exposed Photographic Plates: Method of Measuring Diffusion.* **J. Eggert** and **G. Archenhold.** (Zeits. phys. Chem. 110. pp. 497–513, 1924.)—The first part of the paper is devoted to a description of two methods of measuring the diffusing power of a translucent plate. The first method depends on the fact that when an object is viewed through a diffusing medium the edges appear softened to an extent which depends on the diffusing power of the medium. A convenient form of object is set up and is photographed with and without the diffusing plate 1 cm. in front of the object, the photographic image being three times the size of the object. The region of the photographic image close to the edge of the object is divided into a number of narrow zones, parallel with the edge, and the number of silver particles deposited is counted for each zone. A graph is drawn with the number of the zone as abscissa and the number of particles as ordinate. The slope $dy/dx$ of this graph is taken as a measure of the diffusing power, the angle of slope decreasing with increase of diffusion. The second method of measurement depends upon the fact that the ratio of the apparent brightnesses of a white and a black object is reduced by the interposition of a diffusing medium. A plate of opal glass is covered with a black card containing four small apertures 15 × 5 mm. These are caused to have brightness in the ratios 1 : 3·5 : 12·9 : 50 by placing over each aperture a piece of exposed photographic plate of the required transmission factor. This system is then photographed, and the densities of the images of the four apertures are measured by means of a Martens photometer. The densities are plotted as ordinates against the known brightnesses of the apertures as abscissæ on a logarithmic scale. This procedure is carried out with and without the interposition of the diffusing plate under investigation, and the graphs are found to be sensibly straight lines. If $\theta$ and $\theta'$ are the angles of slope of these lines without and with the medium respectively, the diffusing power may be expressed by the function $(\tan\theta - \tan\theta')/\tan\theta$. The limiting value of this function, expressing complete diffusion, is unity. The same thing may be otherwise expressed thus: If $q$ be the ratio of the brightnesses of two sources without the interposition of the medium, and $q_\sigma$ the corresponding apparent ratio with the medium interposed, then the diffusing power $\sigma = 1 - \{\log q_\sigma/\log q\}$.

The second part of the paper gives a description of results obtained with various emulsions. It is found that (*a*) the diffusion increases with the distance between the medium and the sources, at first proportionally, but afterwards more slowly, approaching a limiting value which is a characteristic of the medium; (*b*) for similar emulsions this limiting value of $\sigma$ is approximately proportional to the density $s$. Hence it follows that, *for small values*, $\sigma$ is additive; (*c*) for different emulsions the diffusion increases with the silver grain size; (*d*) the diffusing power $\sigma$, measured as described above, is in agreement with visual estimation as regards the order in which different plates are placed.

Among other results obtained, it is found that a plate exposed to a bright light for a short period has a lower value of $\sigma$ for the same value of $s$ as compared with a similar plate exposed to a lower brightness for a longer period. Further, it is found that an unexposed plate has a certain diffusing power, which is, naturally, independent of the silver grain deposition. **J. W. T. W.**

**2491.** *The Photoelectric and Phosphorogenic Effect.* **M. Curie.** (Comptes Rendus, 178. pp. 2244–2246, June 30, 1924.)—In continuation of the work of Lenard, the author has investigated the effect of the presence of a salt of bismuth upon the photoelectric effect, the fluroescence and phosphorescence exhibited by calcium sulphide. The concentration of bismuth in the mixture ranged from zero to $5 \times 10^{-2}$. The results obtained indicate that pure calcium sulphide containing no bismuth exhibits no photoelectric effect. When the phosphorogenic material (bismuth) is present the photoelectric effect is observed, but there is no evident relation between the magnitude of the effect and the concentration of the bismuth. The greatest photoelectric effect was observed when the concentration of the bismuth was 1 or 5 parts per 100 of the mixture. A greater photoelectric effect was, however, observed in the case of a specimen of calcium sulphide containing bismuth, prepared differently and containing lithium. There appeared to be no relation between the photoelectric and luminescent effects observed. **J. S. G. T.**

**2492.** *The Size-Frequency Distribution of Grains of Silver Halide in Photographic Emulsions and its Relation to Sensitometric Characteristics. VI. Photographic Densities derived from Size-Frequency Data.* **E. P. Wightman, A. P. H. Trivelli and S. E. Sheppard.** (Eastman Kodak Co. Research Lab. Comm. No. 200. J. Phys. Chem. 28. pp. 529–543, June, 1924.)—The object of the present work was to find a method of deriving experimentally the densities for any given exposures in the characteristic H and D (density-log exposure) curve of a simple photographic emulsion from its grain size-frequency distribution. That of a Seed-Lantern emulsion has been determined, and it was found that neither the simple exponential nor the Gaussian type of equation would fit it. A satisfactory equation, however, *viz.* $y = Ae^{-k(\ln x - a)^2}$, results from the assumption that the growth of the particles in the emulsion is proportional to their size (surface, or less accurately, their projective area) at any moment. The formation of a photographic emulsion on the basis of this assumption appears reasonable, and has been accepted as true for a number of cases. It is shown why an equation of the same fundamental form (but not those used previously by the authors) can be used to represent both uniform diameter and uniform projective area classification. A method of determining density values from size-frequency data has been worked out, and consists in converting the size-frequency and projective area distribution. Then, by applying a factor for the increase in size of the silver halide grain on development, the area distribution of developed grains is found, and finally the composite density D is calculated by means of the equation

$$D = \log_{10} 1/(1 - [r_1 n_1 x_1 + r_2 n_2 x_2 + \ldots r_n n_n x_n])$$

where $r_1$, $r_2$, etc., are the expansion ratios, $n_1$, $n_2$, etc., are the frequencies of grains of each class-size per unit area of plate, and $x_1$, $x_2$, etc., are the mean class sizes. A comparison of the synthetic density curve found in this way, with the curve obtained by means of the thalofide cell densitometer, shows poor agreement. Possible explanations of this are given. [See also Abstracts 1125 (1923) and 74 (1924).] **H. H. Ho.**

**2493.** *Chemiluminescence of the Iodide of the Millon Base.* **A. Petrikaln.** (Zeits. f. Physik, 25. 4–6. pp. 292–298, 1924.)—The author deals with the spectrum; the energy account; the relations between these. The energy of decomposition upon heating, 70 cal, is sufficient to account for the luminescence. A. D.

**2494.** *Fluorescence.* **S. Valentiner** and **M. Rössiger.** (Preuss. Akad. Wiss. Berlin, Ber. 16. pp. 210–215, 1924.)—The efficiency-ratio of fluorescence to the incident radiation depends on the wave-length of the incident radiation; it is constant or increases slightly with increasing wave-length until a maximum fluorescence is reached; thereafter it falls off sharply. In the neighbourhood of concentrations of $10^{-7}$ to $10^{-5}$ grm./cm.$^3$ it increases with increasing concentration. A. D.

**2495.** *Viscosity and Fluorescence.* **F. Perrin.** (Comptes Rendus, 178. pp. 2252–2254, June 30, 1924.)—In a previous note the author has shown that the fluorescent power of a dissolved substance decreases exponentially when the concentration increases: $\Phi = \Phi_0 J^{-kc}$. For one and the same fluorescent substance the value of the constant $k$ must depend on the viscosity of the solutions considered. If, in fact, the proximity of a molecule of the same kind can hinder the fluorescence of a molecule which has absorbed a quantum of exciting light, as well at the moment of return to the normal state as at the moment of absorption, the constant $k$ will depend on the coefficient of diffusion of the dissolved molecules. For example, if a molecule cannot be fluorescent when it finds itself at a distance less than $\epsilon$ from a molecule of the same kind, either at the instant of absorption or at the instant of return to the normal state, $k$ would be twice as small for a solid solution as for a solution slightly viscous. In the first case, in fact, an isolated molecule remains isolated, although if an important diffusion is produced during the mean duration of the critical state the probabilities of isolation at the beginning and at the end of that state are independent. With these simple hypotheses the following expression is obtained (N being Avogadro's number):

$$K_s = \tfrac{1}{2}K_l = N\int_0^{\epsilon} 4\pi r^2 dr = \tfrac{4}{3}\pi N\epsilon^3$$

Depending on the experimental values of $K_l$ the following distances of protection $\epsilon$ are obtained: for fluorescent blue $\epsilon = 3{\cdot}4{\cdot}10^{-7}$ cm., for uranine $\epsilon = 2{\cdot}5{\cdot}10^{-7}$ cm., for quinine $\epsilon = 1{\cdot}1{\cdot}10^{-7}$ cm. Viscosity has another important action on the phenomenon of fluorescence; it influences the mean duration of the critical state in which the molecule subsists between the instant in which it absorbs and that in which it re-emits, and consequently influences the duration of the luminescence after excitation has ceased. J. J. S.

**2496.** *Absorption Series from Phosphores.* **F. Schmidt.** (Ann. d. Physik, 74. 4. pp. 362–380, June, 1924.)—Cases found in which the number of quanta is so large that the effective orbit is far wider than the diameter of the atom as usually reckoned. The smaller the nucleus, the greater the tendency towards long waves, and *vice versa.* A. D.

**2497.** *The Polarization of Sodium Resonance Radiation in Magnetic Fields.* **E. Gaviola and P. Pringsheim.** (Zeits. f. Physik, 25. 4-6. pp. 367-377, 1924.)—The observations of Wood and Ellet [see Abstract 1861 (1923)] on the polarisation of resonance radiation of Hg and Na vapours under the influence of a magnetic field may be entirely explained by consideration of the phenomena as Zeeman effects, provided that only the anomalous Zeeman effects of the various atoms concerned are taken into account. The most important of the previously unverified deductions made from this explanation is that the two components of the D line should behave quite differently, for while the $D_2$ line, for a definite orientation of the magnetic field with respect to the electric vector of the exciting radiation, and in a given direction of observation, should show considerable partial polarisation, the $D_1$ line should remain quite unpolarised. To test this deduction the same arrangement as used by Wood and Ellet is employed, the magnetic field being parallel to the exciting beam and observations being made perpendicular to this direction. The source of light is a Na-K arc in quartz.

In a field of 200 gauss and at a temperature of 125° the $D_2$ line, when examined through a Savart plate and Nicol, showed the required horizontal interference bands, while the $D_1$ line is homogeneous throughout, confirming the theoretical conclusion. The polarisation of the resonance radiation should also be independent of the polarisation of the primary light. This is also confirmed experimentally. On theoretical grounds the degree of polarisation of the resonance radiation must depend on the density of the Na vapour, the polarisation decreasing with increasing pressure. This effect may partially, in so far as it depends on the collision frequency between neighbouring atoms, be compensated by increase of the external magnetic field. Again, from theoretical considerations, the degree of polarisation of the $D_2$ resonance radiation must assume different values according to whether the electric vector of the primary radiation is parallel or perpendicular to the direction in which observations are made.

W. V. M.

**2498.** *The Processes during the Radiation of Iodine Bands.* **O. Oldenberg.** (Zeits. f. Physik, 25. 2. pp. 136-159, 1924.)—The author seeks an answer to the question "What changes in the molecule are concerned in the radiation of band spectra?"—a question partially answered with respect to certain types by the quantum theory. The paper discusses a number of results due to other observers and also those of the author on the fluorescence of mixtures of iodine vapour and such gases as $N_2$, $H_2$, $O_2$, $CO_2$, etc., when illuminated by a mercury lamp (quartz) or an aluminium spark. Some of the main conclusions are given below.

I. *Variation of the Ultra-violet Fluorescence of Iodine with Pressure.* (*a*) *Alterations in Intensity.*—The distribution of intensity alters in the ultra-violet (when excited by λ1849) as in the visible when the pressure of the foreign gas is altered. The fluorescence below 4800 observed by Wood and Steubing behaves in a similar way. The cause is connected with a quantum change in the iodine molecule strongly excited by absorption, the change being modified but not originated by external disturbance.

(*b*) *Appearance of New Spectra.*—Contrary to the results for visible iodine fluorescence, the presence of the second gas brings to light new spectra when stimulated with ultra-violet, the strongest being the continuous iodine band at 3460 investigated by Gerlach and Gromann. [Abstract 516 (1924).] With increasing pressure, particularly for $N_2$, the band breaks up into a series of bands. The total intensity, unlike all other fluorescence phenomena in gases and vapours, remains the same up to atmospheric pressure. The series of bands cannot, however, be other than a modified form of the single band, since such phenomena as wave-length limit, maximum intensity, rapid fall towards long waves, and gentle decrease towards shorter wave-lengths are the same in both. The bands may be attributable to a molecule such as IH. Photographs are given.

II. *Electron Affinity Spectrum of the Iodine Atom.*—The band 3460 is not to be attributed to the electron affinity spectrum of iodine, as thought by previous observers. A discussion of energy considerations leading to this result is given.

III. *Spectra produced by Ionic Recombination.*—The band 3460 is probably the result of the combination of atomic ions $I^+$ and $I^-$. Various possibilities of the decomposition of iodine molecules into $I + I$, $I^+ + I^-$, $I^+ + I$, $I^- + I$, are discussed; and again energy considerations lead to the choice of $I^+ + I^-$, but it is probable that the change to the normal iodine molecule is not effected in one stage owing to correspondence considerations. According to this conception the long wave bands arise from the formation of molecules with more violent vibration of the "kernel." Evidence is given for this.

IV. *Photochemical Luminescence.*—On the addition of $N_2$ to iodine vapour a new band appears in the green during ultra-violet excitation. This remains undiminished at higher pressures, and is to be ascribed to an IN molecule. This band, together with the 3460 band, is to be regarded as photochemical luminescence in distinction to true fluorescence. The observations lead to the suggestion that the flourescence is diminished by pressure, whereas photochemical emission is developed.

V. *The Absorption Series of Iodine Atoms.*—The theoretically possible appearance of atomic lines in the fluorescence of iodine vapour and a mixed gas cannot be observed. On the basis of an accidental determination of intense silver lines in the iodine line spectrum it was surmised that the transition probabilities for iodine atoms are much less than for the silver atoms.

In conclusion, the relations between the elementary changes founded on the study of the banded radiation of iodine molecules are collected together. The known iodine bands are produced together during fluorescence, and are therefore to be connected with the neutral molecule.

W. V. M.

**2499.** *Quantum Theory of Band Spectra.* (Nature, 113. pp. 874–875, June 14, 1924.)—The arrangement of the lines in band spectra may be described by associating successive integers *m* with successive lines, when their wave-numbers are found to be given, to a near approximation, by an expression of the form $A + Bm + Cm^2$, where A, B, C are constants. The radiating systems here involved are molecules instead of atoms, so that, in addition to the energy associated with electrons, two other types of energy may be radiated, due to rotation of the molecule as a whole and to vibration of the constituent atomic nuclei. Each of the three types is subject to the rules of generalised quantum mechanics, and the frequency of radiation emitted is given by dividing the *total* decrease of energy by Planck's constant $h$. When the initial and final states of the molecule differs only in respect of rotation, the spectrum should consist of a few equally spaced lines in the far infra-red, some of which have been observed. Where rotation is accompanied by change in vibrational energy of the nuclei, a double system of lines in the near infra-red is to be expected, such as that found by Imes in the case of hydrogen chloride. Much more energy is liberated when a change in electron configuration accompanies these other changes, and the resulting emission is usually in the visible or ultra-violet regions. In spite of the theoretical complexity, important progress has been made in the case of the cyanogen bands by Kratzer. There are outstanding difficulties in the absence of only one line at the centre of the infra-red bands and in the alternate spacing of lines in the helium bands which involves the introduction of half-quanta. F. S.

**2500.** *Remarks on Tartakowsky's Paper "On the Theory of Band Spectra."* **A. Kratzer.** (Zeits. f. Physik, 26. 1. pp. 40–43, 1924.)—Tartakowsky's paper [see Abstract 2078 (1924)] contains for an anharmonic oscillator a natural upper limit for the oscillation quantum number of molecules. Since the present author does not agree with the procedure, he now discusses the problem anew. From the quantum conditions for the anharmonic oscillator it is concluded that the oscillation energy has for upper limit the work of dissociation of the molecule; this demands, however, no limit in general for the quantum number in contrast to the conclusions of Tartakowsky. In no case has such a maximum quantum number been obtained by means of the formulæ given by Tartakowsky. The paper is entirely mathematical. H. H. Ho.

**2501.** *Ionisation in Stellar Atmospheres.* **Cecilia H. Payne.** (Harvard Coll. Obs., Circ. 256. [8 pp.], 1924.)—The intensities of lines associated with He, He +, Si, Si +, Si + +, Si + + +, and C + are measured from objective prism spectra. A temperature scale is derived for the reversing layers of the giant stars from types AO to O*d*. This scale is consistent for the different lines, and the electron partial pressure in the layer of origin is approximately $10^{-4}$ atmospheres. The intensity changes of a number of lines attributed to oxygen, nitrogen and sulphur are also tabulated. Hence the ionisation potentials of O +, N +, N + +, S +, S + +, and C + + are calculated and are found to be in general agreement with laboratory measurements. A. Wh.

**2502.** *Some Correspondence Considerations.* **W. Lenz.** (Zeits. f. Physik, 25. 4–6. pp. 299–311, 1924.)—To the few cases of elementary radiation processes which have received no treatment by the correspondence principle belong those band emissions of molecules which take place *via* the co-operation of the luminous electron. [See Abstract 1071 (1920).] The series of band edges may be regarded from the correspondence standpoint as combination oscillations, which arise through the periodic disturbance of the luminous electron of the molecule by the motion of the nuclei. Peculiarities in the course of the intensity in these series are explained on this basis, and correspondence considerations of a similar kind lead to a discussion of the proper standpoint for the treatment of the widening of the spectral lines by pressure. To complete the subject a correspondence discussion of the Compton effect is included. H. H. Ho.

**2503.** *The Absolute Intervals of the Optical Doublets and Triplets.* **A. Landé.** (Zeits. f. Physik, 25. 1. pp. 46–57, 1924.)—The relationship between the optical and relativity Röntgen doublets, expressed in their common multiplet structure, etc., led to the conclusion [see Abstract 2104 (1924)] that both kinds of doublet depend on corresponding model-like processes in the atom. In consequence, the relativity interpretation of the Röntgen doublets (Sommerfeld) must be regarded as unsatisfactory, while from the multiplet data the explanation of optical doublets as the relativity energy difference of two eccentric elliptic orbits of luminous electrons must perhaps also be rejected, so long as the basic principles of the Bohr theory are adopted. The above relationship is now shown to be determined from the absolute intervals of the optical doublets and triplets, being derived from the universal constants, effective quantum and atomic numbers, known regularities of the intervals $\Delta\nu$ in the periodic system, and the proportionality factor. Conversely, the quantities $Z_i = Z - s$ are derived from the interval formula, the division quantity $s$ being constant and $= 4$, except for the first elements, when $s = 2$, both results being in accord with Bohr's system of interlaced $n_k$-orbits. The theoretical derivation of the interval formula [from the Paschen-Götze data, ranging from Li $\Delta\nu = 0{\cdot}34$ to Ra $^{+}\Delta\nu = 4858{\cdot}6$] depends on the fact that the luminous electron owes the complexity of its terms essentially to the innermost orbit change. Use can then be made of Sommerfeld's theory of the relativity L-doublets, and this is now suitably extended to optical doublets and triplets. This relativity interpretation, however, is in conflict with the optical spectra and other results from the quantum theory of atomic structure, as is the case with the Sommerfeld theory of Röntgen doublets, and can hardly be used for explanation of the spectral terms without essential alteration in fundamental principles. The theory is then developed for an eventual explanation of optical and Röntgen doublets by means of magnetic forces. H. H. Ho.

**2504.** *Vanadium Multiplets and Zeeman Effect.* **W. F. Meggers.** (Washington Acad. Sci., J. 14. pp. 151–159, April 4, 1924.)—In this note the author gives a few examples of several types of multiplets in the arc spectrum of vanadium, together with the observed and calculated Zeeman effects for the spectral lines. Since the first note was published the region of the spectrum from violet to red (4500 to 6500 Å.), in which wave-length data of inferior quality existed, has been remeasured on the international scale. Most of the multiplets here discussed are selected from this interval. In the tables given, each of which gives data for one multiplet, the scheme of term combinations is first given, and then the observed and calculated Zeeman effects characteristic of the spectral lines are compared. In the arrangement of a multiplet each spectral line is represented by its wave-length in air, above which its arc intensity and temperature class are given, while the corresponding vacuum wave number is directly below. The notation for spectral terms proposed by Landé is employed. J. J. S.

**2505.** *Penetration of Waves and their Rays into a Gradually Varying Medium.* **J. A. Wilcken.** (Cambridge Phil. Soc., Proc. 22. pp. 124–131, May, 1924.)—The author's objective in this paper is to elucidate the questions: (1) Does a gradual change of refractive index cause any disintegration of an incoming wave system, comparable to the reflection as known in abrupt transition? (2) Is the ordinary refraction law, $\mu \sin \theta =$ constant, strictly applicable to a medium with a continuously varying index? A paper by the late Lord Rayleigh [Proc. Lond. Math. Soc. 11. pp. 51–56, 1880], in which he showed that reflection takes place in a gradually varying medium, but the attenuation of the incoming wave may be negligible in many practically important cases.

The author's conclusions are: (*a*) A non-homogeneous medium of slowly varying properties causes reflection, but of negligible intensity. (*b*) In such a varying medium the ordinary refraction law of the ray paths, determined as orthogonal to the fronts of constant phase, does not hold, the refraction being slightly less in amount than according to Snell's law. The deviation becomes less as normal incidence is approached. (*c*) Total reflection may occur for a very oblique ray, if the layer be thick enough, the ray path then bending round in a continuous curve and emerging at an angle equal to that of incidence. He finds that in most of the investigations published hitherto the validity of Snell's law has been implicitly or explicitly assumed, and to show how the error arose he first gives the usual solution, starting from the general wave-equation, after separating the time variable: $\partial^2 U/\partial x^2 + \partial^2 U/\partial y^2 + k^2 U = 0$, where $k$ is a real continuous function of $x$ only, of the usual meaning, $k = 2\pi/\lambda$. He then starts with the assumption $U = e^{\Phi}$, $\Phi$ being a complex function of $x$ and $y$, subject to $\partial^2\Phi/\partial x^2 + \partial^2\Phi/\partial y^2 + (\partial\Phi/\partial x)^2 + (\partial\Phi/\partial y)^2 + k^2 = 0$. A slow variation of the medium is specified in the form $k = k_0 + k_1 x + \ldots$, $k_1$ being a small constant, higher powers of which may be neglected as compared with $k_0$. The solution is then approached by taking $\Phi = \pm i(lx + my) + px + qy + rx^2/2 + sy^2/2 + txy$, where $l^2 + m^2 = k_0^2$, so that $l$ and $m$ are proportional to the direction cosines of the incident ray, or wave normal, and $p, q, r \ldots$ take the meaning of small coefficients, not necessarily real, to correcting terms, to be added on account of the (slow) variation of $k$. Two special cases not leading to complicated expressions are worked out. G. W. DE T.

**2506.** *Half-Integral Quantum Numbers in the Theory of the Stark Effect and a General Hypothesis of Fractional Quantum Numbers.* **A. M. Mosharrafa.** (Roy. Soc., Proc. 105. pp. 641–650, June 2, 1924.)—Mention is made of indications found by various investigators, *e.g.* W. E. Curtis, in his experimental study of helium bands [see Abstract 1856 (1923)], of the occurrence of fractional quantum numbers. K. F. Niessen ("Zur Quantentheorie des Wasserstoffmolekülions") observes certain discontinuities in the energy graphs between symmetrical and asymmetrical models which strongly suggest the occurrence of half-integral quantum orbits for the latter. A mathematical line of reasoning is followed in which the introduction of half-integral quantum numbers is consistent with the resolution of lines in the Stark effect. It is shown that half-integral components are to be expected much less in the case of the higher than of the lower members of the Balmer series. A general formula is suggested having the special merit of leading to the classical law of least action as a limiting case. A. B. C. L.

**2507.** *The Metastable State in Mercury Vapour.* **H. W. Webb.** (Phys. Rev. 24. pp. 113–128, Aug., 1924.)—The persistence of the "radiation" produced by 4·9-volt impacts in mercury vapour was measured in a four-electrode tube of the type usually employed in resonance potential measurements, consisting of an equipotential kathode of simple design, an inner grid G for controlling the velocity of the impacting electrons, an outer photoelectric grid H, and a photoelectric plate P. A.c. and d.c. voltages were applied to the two grids in such a way that the electrons had sufficient velocity to excite the radiation only in alternate half-cycles, and that the photoelectric current to the electrometer alternated in direction simultaneously. As a result of the persistance of the radiation there resulted a decrease in the current, with increasing frequency, reaching a minimum at 1800 cycles for a distance between grids of 17 mm. and at 3800 cycles for a distance of 8·5 mm. These results did not vary much with pressure, 0·003 to 0·032 mm. They show a lapse of time between the excitation and the arrival of the first radiation at the plate P of about 1/3600 and 1/7600 sec. respectively. A mathematical discussion shows that the diffusion of the radiation by repeated emission and re-absorption (the "imprisonment" of radiation theory) cannot account for these results. A calculation, based on the assumption that the excited atoms remain in a metastable state and carry the energy of excitation to the photoelectric surfaces and there gives it up, gives results in very close agreement with the observations. The conclusion is that a metastable state is formed by the atoms excited by the 4·9-volt electron impacts, and that these are the effective ones in producing the photoelectric response in the tubes. In these experiments the $2p_2$ state is the only one excited by the impacts in appreciable amount. How these results can be reconciled with the Bohr theory, according to which the $2p_2$ state is not metastable, is not clear. AUTHOR.

**2508.** *The Absorption Spectrum of Bromine.* **P. Bovis.** (Comptes Rendus, 178. pp. 1964–1966, June 10, 1924.)—The absorption spectrum of bromine in both gaseous and liquid states has a large band commencing in the red and attaining its maximum in the violet. The gaseous condition has been studied numerically by Ribaud (Ann. de Physique, 12. p. 178, 1919), and the author has, in the present paper, extended the investigation to liquid bromine, spectrophotometric measurements being made, using very thin layers of the liquid between quartz plates. A Nernst lamp is used as source, and Glazebrook prisms eventually replace the layer of bromine and enable the absorption to be calculated. The wavelengths are obtained by comparison with a mercury-arc spectrum.

It is found that the maximum optical density corresponds to a wavelength 0·417 μ. Ribaud had shown that in the gaseous condition a maximum absorption occurs at 0·415 μ, and hence the maxima appear to coincide, but the absorption related to the same mass of bromine are very different, the optical density of the liquid being more than double that of the vapour. W. V. M.

**2509.** *Application of Spectographic Analysis to the Examination of Rare Elements in Substances found in Italy.* **C. Porlezza** and **A. Donati.** (Accad. Lincei, Atti, 33. i. pp. 232–237, March 16, 1924.)—In a preceding note the value of spectrum analysis in detecting rare elements and in serving as a control in the case of ordinary analysis has been considered. Modifications have been introduced into the method applied by Urbain: (1) Besides making use only of the violet or ultraviolet portion of the spectrum as in Urbain's method, the part extending towards the red has been used, with the help of a spectrograph, giving sufficient dispersion in this region. (2) The analysis of the materials has been completed in two ways: (*a*) by the spectrographic examination of the precipitates obtained with single analytic groups and with insoluble residues eliminating silica if it occurs; (*b*) by the spectrographic examination of precipitates or residues obtained in fractionating precipitates of the single groups, especially in the case when the results have not been sufficiently exact in the preceding research.

In the present note are described investigations which extend the method of spectrographic analysis to various other natural substances occurring in Italy, chiefly rocks, in order to show the presence of elements which are perhaps fugitive through occurring only in traces, and at the same time possibly to establish the presence of elements not hitherto proved to occur in Italian substances. Various rocks from different parts of Italy are considered in detail, but the research has a preliminary or provisional character, having been confined to one region of the spectrum only. It has, however, already given results of some interest. J. J. S.

**2510.** *The Fine Structure of the Yellow Helium Line* 5876A. **L. S. Ornstein** and **H. C. Burger.** (Zeits. f. Physik, 26. 1. pp. 57–58, 1924.)—Measurements of the intensity relation between the components of the line 5876 give a result 1 : 6 as opposed to the theoretical 1 : 2, and it is concluded that this yellow line is not a normal doublet of the $\pi$-$\delta$ type. It may be the result of intercombination between two singulet terms or an entirely new type of multiplet. W. V. M.

**2511.** *The Structure of the Iron Spectrum. Part II.* **O. Laporte.** (Zeits. f. Physik, 26. 1. pp. 1–22, 1924.)—This paper extends earlier published work [see Abstract 1481 (1924)] on the iron spectrum, in which, according to the Sommerfeld method, the lines were regarded as combinations and intercombinations of terms of the triplet and quintet systems. New work has meanwhile been published by Walters [see Abstract 1480 (1924)], and the present paper now establishes terms of the septet system and their intercombinations with the fundamental term *d* of the iron spectrum. From a comparison of the intensities of the intercombinations between the three series systems of iron an especially close connection is opined between the triplet and quintet systems, from which the septet system is excluded. Confirmation of conclusions with respect to term combinations in Part I is afforded, and a series of new triplet and quintet terms completed, while about a quarter of the total number of iron lines have now received interpretation. Very complete tables are included. H. H. Ho.

**2512.** *Structure of the Iron Spectrum.* **Hilda Gieseler** and **W. Grotrian.** (Zeits. f. Physik, 25. 2. pp. 165–172, 1924.)—From previous work [see Abstract 1474 (1924)] it was concluded that the normal state of the iron atom corresponds to a *d*-term of the quintet system. Laporte has investigated the multiplets of Walters and identified a series whose limit corresponds to an ionisation potential of 5·9 volts. Farther work by the authors, using the plane grating spectrograph in the Einstein tower, which has a dispersion of 2 Å. per mm. in the second order, has led to the analysis of a new multiplet. This belongs to a further *d*-term group of the quintet system. This group corresponds to an ionisation potential of 8·15 volts. F. S.

**2513.** *Relations Between Pressure-Shift, Temperature Class, and Spectral Terms of the Iron-Lines.* **M. A. Catalán.** (Nature, 113. pp. 889–891, June 21, 1924.)—A review of past work, together with an account of the author's latest contributions to the subject, too detailed for abstraction. Lines forming a multiplet are equally affected by pressure, and different multiplets are differently affected. It seems, therefore, that the effect depends on the radial quantum numbers. Large orbits may be more affected than small ones by pressure; consequently transitions will be more affected between large orbits than between small ones. The temperature effect will be parallel to the pressure effect. A. C. M.

**2514.** *The Arc Spectrum of Silicon in Relation to Spectrographic Analysis.* **C. Porlezza.** (Accad. Lincei, Atti, 33. i. pp. 193–197, March 2, 1924.)—The author has previously pointed out the existence of a band spectrum in the arc spectrum of this element, and in the present paper he gives measurements of the positions of the lines in this band, the wave-length of the head of the band being $\lambda = 2414$. The wave-lengths of eighteen lines are given in a table. These extend from 2419·1 to 2426·1. There is an almost continuous background in which individual lines cannot be noted. There are about seventy lines in an interval of less than 60 Å.U. The author in the present note considers some rock specimens which were examined and in part analysed by Aloisi and described in his volume on Mt. Capanne, in the island of Elba. These specimens of rock are eighteen in number, and are divided into nine different types. The analysis of these rocks is given, and the percentages of the various components are recorded in a table. The appearance of the band spectrum of silicon in the various specimens is considered. With a percentage of $SiO_2$ of 35 some of the bands and lines appear. With about 60 % of silica a spectrum of notable intensity is observed, and such as interferes with the observation of the lines belonging to the other elements present. The conclusion is drawn that in spectrographic analysis it is necessary to eliminate the silica when this substance is present in notable quantity. J. J. S.

**2515.** *Fresh Regularities in the Spectrum of Silicon Tetrafluoride.* **C. Porlezza.** (Accad. Lincei, Atti, 33. i. pp. 283–287, April 13, 1924.)—In addition to those given by Dufour, three new groupings occur in the band spectrum of silicon tetrafluoride: $(X')$, $N = 23580 - 166{\cdot}5\,m - 3{\cdot}5\,m^2$ $(m = 0, 1, 2, 3)$; $(Y')$, $N = 23624 - 165{\cdot}5\,m - 3{\cdot}5\,m^2$ $(m = 0, 1, 2, 3, 4)$; $(Z')$, $N = 23416 - 161{\cdot}5\,m - 5{\cdot}5\,m^2$ $(m = 0, 1, 2)$. For $X'$ and $Z'$ the coordination is shown by comparison with the results obtained by Dufour in the study of the longitudinal Zeeman phenomenon. Six other groupings, each of two components, are also observed. T. H. P.

**2516.** *The Spectrum of a Sodium Vacuum Arc. I.* **H. Bartels.** (Zeits. f. Physik, 25. 4–6. pp. 378–401, 1924).—A vacuum arc which burns between iron as positive and sodium as negative electrodes may be divided into several parts, the various portions showing important differences in the intensity relationships for various lines. In Part I of the paper the author describes the experimental arrangement of such an arc, the quantitative measurements of the intensities of the lines, and the physical conditions under which they appear. The second portion of the paper discusses the conclusions to be drawn with respect to the excitation and emission processes.

I. The sodium is contained in a small porcelain tube, while the anode is a small iron hammer, the whole being enclosed in a glass sphere with four additions connecting to electrodes, pump, etc., the apparatus having a quartz window through which the observations are made. The arc shows characteristic division into various parts. Near the sodium, where the arc emerges, the flame is brilliant yellow, but this " core " changes more or less continuously to a surrounding " shell," which often fills the whole arc vessel and is coloured a deep green. It is easily seen that in the core the D lines are very bright, but that in the green shell the intensity of the diffuse series lines is much stronger. This total arc, A, burns until all the sodium is evaporated, but just before going out it changes suddenly to a second type of arc, B, which burns a dull yellow and without any division into " zones." The causes of this change are discussed.

The experimental methods of determining the relative intensities of given lines are now described, the source being so arranged that part of the slit is illuminated by the yellow light of the inner arc and part by the green light of the shell. Arc B is similarly examined. A modification of a photometric method used by Koch is described, whereby large intensity ratios may be directly measured, and by this means the changes in intensity occurring in the transition from " core " to " shell " of A, and also from A to B, are measured. Two diagrams are given showing the relative intensities of various lines in different arcs.

II. It is concluded from the measurements that the transitions allowed by the azimuthal selection principle are highly favoured in the excitation by electronic collision. The results are also regarded as in agreement with Rupp, who found that the HS is produced by the excitation of neutral atoms, while the NS is the result of recombination between ionised atoms and electrons.

A continuous spectrum at the end of NS is described which has the same characteristics as the continuous spectrum at the end of the Balmer series, and therefore, according to Bohr, is to be explained as due to the addition of free electrons to the ionised atoms. W. V. M.

**2517.** *The Absorption Lines in the Spectrum of the Metallic Spark in Water.* **E. O. Hulburt.** (Phys. Rev. 24. pp. 129–133, Aug., 1924.)—These spectra, seven of which are reproduced, consist of a continuous background crossed by bright and dark lines characteristic of the metal. For Al, Bi, Cd, Au, Ir, Pb, Mg, Pt, Rd, Ag, Sn and Zn the absorption lines are those which are reversed in the arc. For Sb, Co, Cr, Cu, Fe, Mo, Ni and W the water spark shows as absorption lines all the lines reversed in the arc, and in addition about 400 absorption lines in all, which are not listed as reversed in the arc. Some of these are mentioned. AUTHOR.

**2518.** *Directions of Emission of Photo-electrons Liberated by Röntgen Rays.* **W. Bothe.** (Zeits. f. Physik, 26. 1. pp. 59–73, 1924.)—Directions in air, MeI, EtCl and chloroform vapour were investigated by Geiger's method. The mean angle is smaller the harder the rays; the breadth of scattering depends on the proximity of the nearest absorption-wavelength of the substance. Asymmetry appears both in the mean angle and in the breadth of scattering, and depends upon the wave-length of the Röntgen rays and upon the atomic weight of the substance. A. D.

**2519.** *Change of Colour in Rock-Salt Due to X-Rays.* **P. Ludewig** and **F. Reuther.** (Zeits. f. Physik, 26. 1. pp. 45–53, 1924.)—The authors refer to experiments previously described [see Abstract 558 (1924)], and to Przibram's criticism of the same. New experiments on rock-salt are described. The plates A and C were exposed to the same radiations as previously for a further period, making a total of 137 days, and a curve is given showing the diminution of the white content during the whole series; the rate of diminution towards the end of the period is small. When the plates were re-examined, after being kept for 14 and 18 days in the dark, very little change in the colour was observed. Bright blue rock-salt changed its colour under the influence of the radiation, passing through a grey, colourless phase in one day, and then became a dirty yellow; the white diminished and the black increased during the whole period, while the coloration increased from the second day on. Dark blue rock-salt changed from tint 59 to tint 63 to 75, *i.e.* to a blue-green. Here, as in the former case, the discoloured substance was often very spotty. The white remained nearly constant and the black increased. The coloured rock-salt contained colourless patches. These were much more sensitive than ordinary colourless rock-salt, as is shown by the curves for the change in the white content and in the coloration. For the former a value, which with the ordinary salt is reached in six days, is attained in one day with the colourless pieces taken from the blue specimens. The tint is the same in both cases. H. N. A.

**2520.** *Effect of Temperature on the Regular Reflection of X-Rays from Aluminium Foil.* **E. H. Collins.** (Phys. Rev. 24. pp. 152–157, Aug., 1924.)—The powder method of analysis was used, a coil of the foil being placed at the centre of the spectrometer in an electric furnace provided with openings for the X-rays. Intensity measurements for the scattered rays, wave-length 0·710 Å., were obtained with an ionisation chamber, for temperatures 80°, 310° and 600° C. The scattering curve for 80° C. shows peaks at 17·4°, 20°, 28·7° and 33·8° (for planes 111, 100, 110 and 311). These are displaced for the higher temperatures because of the expansion, and are also decreased in intensity, the ratios for $I_{600}$ to $I_{80}$ being respectively 0·86, 0·815, 0·56 and 0·71. These ratios are considerably less than those predicted by the Debye theory, 0·94 to 0·81.

*Relative Spacing of Crystal Planes in Aluminium Rod and Foil.*—The angles of the peaks are from 0·4° to 0·7° less for the foil than for the rod, showing that the planes in the foil are about 1·5 per cent. farther apart as a result of the rolling. This difference is not decreased by heating to 600° C. AUTHOR.

**2521.** *The Absorption Spectra in the X-Ray Sphere.* **D. Coster.** (Zeits. f. Physik, 25. 2. pp. 83–98, 1924.)—A new set of measurements is given on the fine structure of the K-border of the elements Ti, V, Cr and Mn and the $L_{III}$-border of the elements Sn, Sb, Te and I, and it is shown that the character of the fine structure depends on the chemical condition of the elements in question. An absorption line at the soft side of the chief border only happens with these elements when the element is in a higher degree of oxidation. An attempt is made to give a qualitative explanation of the appearance called forth by the fine structure. A full description, with diagram and photograph of the apparatus used, is given, and the results are recorded in both graphical and tabular forms. A. E. G.

**2522.** *Total Reflection of X-Rays.* **N. Carrara.** (N. Cimento, 1. pp. 107–114, Jan.–April, 1924.)—A brief general account is first given of the work of observers who have sought to prove the existence of refraction of X-rays, the experiments of Hurion and Izarn, Gouy, Barkla [see Abstract 687 (1916)], Webster and Clark, Duane and Patterson, Stenström and Compton are briefly discussed. In the present paper experiments on the total reflection of X-rays are described and a diagram of the experimental arrangement is given. An attempt is also made to ascertain by direct measurements the length of X-ray waves with an ordinary diffraction grating. A. E. G.

**2523.** *The Refraction of X-Rays in Iron Pyrites.* **R. v. Nardroff.** (Phys. Rev. 24. pp. 143–151, Aug., 1924.)—Preliminary values of $\delta = 1 - \mu$ were obtained by reflecting the first and fourth orders from a natural face of the crystal. Then, as suggested by Bergen Davis, by grinding the crystal so as to decrease the angle between the beam and the molecular planes to 15′, the angle of bending was increased from 15″ or less to as high as 210″. By calibration of the tangent worm and other precautions, lines were measured to 2″–5″. The values obtained for $\delta \times 10^6$ for MoK$\alpha_1$, MoK$\beta_1$, CuK$\alpha_1$, and CuK$\beta_1$ are $3{\cdot}35 \pm 0{\cdot}2$, $2{\cdot}87 \pm 0{\cdot}2$, $17{\cdot}6 \pm 0{\cdot}5$ and $13{\cdot}2 \pm 0{\cdot}4$. The corresponding values computed from the Lorentz dispersion formula, assuming two electrons in the K ring, are 3·34, 2·66, 17·7 and 13·6. The good agreement seems to indicate that the influence of the natural frequencies of the K electrons is not negligible. The limits of total reflection observed near grazing incidence gave approximate values of the refraction; and the crowding together of MoK$\beta_1$ and MoK$\gamma_1$ near grazing incidence also gave a value of $\delta$ for MoK$\beta_1$.

Wave-lengths of MoK$\beta$, CuK$\alpha$, and CuK$\beta$ are found to be 0·63102, 1·5372 and 1·3892 Å.

Grating space of iron pyrites is found to be 2·7028 Å. AUTHOR.

**2524.** *Determination of the Scattering and Real Absorption Coefficients of X-Rays.* **M. Blau** and **K. Altenburger.** (Zeits. f. Physik, 25. 3. pp. 200–214, 1924.)—A lead box, 15 cm. long, 8 cm. broad and 21 cm. high, was divided into two parts by a horizontal partition, the upper part containing a carbon filament electroscope connected with a thin, vertical carbon rod, which passed down nearly to the bottom of the lower chamber a little to one side of the central line, so as to avoid the impact of the direct X-ray beam. At the centre of one of the ends of the lower chamber was attached a long horizontal tube, containing four diaphragms with 3 mm. holes. Monochromatic or homogeneous X-rays entered at the end of this tube, and passed in a narrow beam along its axis through a hole in the left end of the box, and on through a hole on the other side into an expanding conical tube. To prevent the entry of the characteristic lead radiation into the ionisation chamber the walls were covered with an absorbing layer of copper and aluminium, and to keep down as far as possible the radiation of electrons the aluminium was covered with paraffined paper. The absorber plates were placed either against the left end of the box, when the forward scattered X-rays entered the chamber, or against the right end, when the backward scattered rays produced ionisation; in both cases the absorber plate was separated from the chamber by a plate of celluloid, over which was placed a sheet of paper covered with graphite, with a hole in the centre to allow the X-rays to pass through. The theory is worked out in detail, and equations are obtained by means of which the scattering coefficient can be calculated from the observation. These are regarded as incomplete, but the results obtained are compared with those of Statz, and the values are found to be smaller throughout. The values of $g/\rho$, $(\sigma/\rho)f$, $(\sigma/\rho)b$ and $(\mu/\rho)r$ are given for voltages from 143 to 185 kilovolts on the X-ray bulb, where $g$ is the coefficient of extinction in the absorber, $\sigma$ the coefficient of scattering, $f$ indicates forward scattering, $b$ backward scattering, and $\mu$ the true absorption coefficients; $(\sigma/\rho)b$ diminishes with increase of hardness of the X-rays employed. H. N. A.

**2525.** *A Method of Testing Experimentally the Theory of Bohr, Kramers and Slater.* **W. Bothe** and **H. Geiger.** (Zeits. f. Physik, 26. 1. p. 44, 1924.)—Accepting the explanation of the scattering of X-rays given by Compton and Debye, an experiment seems possible which would render evident the simultaneous production of a scattered radiation quantum and the special electron connected with it. The directions of these two entities do not coincide, and if two counting arrangements are placed so that one receives $h\nu'$ and the other the electron, both must record simultaneously. According to the new theory of Bohr, Kramers and Slater there is no such coincidence in the times. The authors consider such an experiment possible, using two Geiger counters registering on the same film. The scattered X-rays, it is true, will only act by first producing photoelectrons inside the counter, and so a continuous succession of coincidences is not to be expected, but only a statistical connection between the two counts. H. N. A.

**2526.** *The K-Excitation Limit of the Light Elements.* **F. J. v. Wisniewski.** (Phys. Zeits. 25. pp. 297–298, June 15, 1924.)—The author refers to a paper by Holtsmark calling attention to the fact that the above limit for He, Li′, Be″, B‴ and C⁗ is approximately two-thirds of that obtained by extrapolation from the higher elements [see Abstract 2195 (1923)]. For carbon both limits are observed. Disagreeing with the explanation given by Holtsmark, the author assumes that for these elements the two K electrons travel round the nucleus, not in a one-quantum, but in a two-quantum orbit. He shows that the energy E, which must be supplied to remove these electrons from the two-quantum orbit to infinity, is equal to $(4Z - 1)^2 \times 13 \cdot 53/32$ volts. The following table shows the relation between E and the observed K limits:—

| K. | Element. | E. Calculated Volts. | K. Limit Volts. |
|---|---|---|---|
| 2 | He | 20·7 | 20·5 to 21·3 |
| 3 | Li | 51·14 | 52·6 |
| 4 | Be″ | 95·1 | 95 |
| 5 | B‴ | 152·8 | 145 to 150 |
| 6 | C⁗ | 223 | 215<br>234 |

It is assumed in calculating the above values that all the L electrons have previously been removed. It appears then that the two K electrons of these elements move in a stable two-quantum circular orbit. H. N. A.

**2527.** *Crystal Analysis by the Diffraction of X-Rays.* **R. A. Patterson.** (Indust. and Engin. Chem. 16. pp. 689–691, July, 1924.)—A simple account of the principles involved in the examination of crystals by X-rays, with a description of the method employed by Hull; the simple cubic, body-centred cubic, and face-centred cubic space lattices are explained. H. N. A.

**2528.** *The Application of X-Ray Crystal Analysis to Metallurgy.* **E. C. Bain.** (Indust. and Engin. Chem. 16. pp. 692–698, July, 1924.)—Describes the use of the Hull or Debye and Sherrer method in metallography, where it is giving results comparable with those of the metallurgical microscope, though in a different direction. Allotropy seems to be a matter of atomic arrangement; cobalt may be close-packed, hexagonal, or face-centred cubic; γ-iron was found by the author to be face-centred cubic, while α-iron is body-centred cubic. No third allotropic form is indicated between 768° and 900° C. by an alteration of the lattice. The author has examined about twenty series of solid solutions, and found that solution in the solid state takes place by the replacement of solvent atoms by solute atoms in the space lattice of the solvent. There must be a greater attraction between unlike atoms than between like ones; the total volume diminishes, and the shrinking seems to be a measure of the chemical affinity between the metals. When the two metals have different space lattices two kinds of solid solutions are found, A dissolved in B with the B space lattice, and B dissolved in A with the A space lattice. In some cases there is a new lattice for the compound of A and B. There are four different types of space lattice for solid solutions, consisting of Cu and Zn. Coring is a complication due to difference of composition between the first crystallites solidified and the metal subsequently deposited. The sharp lines of the crystallogram are broadened, since the different portions of the metal have different space-lattice dimensions from point to point. Grain-size effects are very important. Fairly small crystals give narrow, uniform diffraction bands; each tiny crystal gives its diffraction image, and these overlap and are indistinguishable; larger crystals give a dashed appearance to the band, the intensity being different at different points. With crystals of submicroscopic size the bands are broadened. The identification of new constituents and the preferred orientation of the crystallites due to cold work are also dealt with. H. N. A.

**2529.** *Reply to Remarks of M. Siegbahn on an Article Dealing with the Use of X-Rays in Chemical Investigations.* **H. Stintzing.** (Zeits. phys. Chem. 111. 1–2. pp. 157–159, 1924.)—Points out that, although Siegbahn dwells on the negative results of the author, the latter has described a number of improvements made by him in the construction and use of incandescent electrode tubes, which enable the characteristic X-rays to be produced with a relatively low vacuum. [See Abstracts 915 (1923) and 2103 (1924).] H. N. A.

## RADIO-ACTIVITY.

**2530.** *The Amount of Emanation in the Radio-active Springs of Brambach and Oberschlema.* **P. Ludewig.** (Phys. Zeits. 25. pp. 280–281, June 1, 1924.)—The author gives the amount of emanation per litre for two springs and three borings at different dates from December, 1922, to February, 1924. At the Oberschlema spring the amount varies from 1840 Mache emanation units per litre to 2600 units; this depends on the flow of water from the spring, diminishing with this. The increase in the winter of 1924 was apparently caused by a long-continued frost, which prevented water from penetrating into the fissures from which the spring is fed. H. N. A.

**2531.** *The Measurement of Small Radio-activities, including those of the Alkali Metals.* **G. Hoffmann.** (Zeits. f. Physik, 25. 3. pp. 177–199, 1924.)—In general the ionization current is composed of two components, one due to single $\alpha$-particles, the ions produced by which cause sudden movements of the electrometer, the other of $\beta$- and $\gamma$-radiation, which gives a more regular movement. In the present paper the author shows how the first component can be eliminated and the second investigated. The ionisation space is contained in a spherical wire "cage" formed of three wires bent into equal circles and fixed at right angles to one another. The cage is kept at 240 volts, and when ionisation takes place inside it, a current flows from it to a central wire electrode connected with an electrometer. The cage is contained in a brass vessel, near the wall of which, at some little distance from the cage, is placed the radio-active preparation. The brass vessel is surrounded by thick lead cylinders, which to a large extent prevent outside radiation from penetrating its walls; the air is then pumped out and replaced by $CO_2$ under pressure. This aborbs the $\alpha$-rays from the preparation and from the walls, and only the $\beta$- and $\gamma$-rays penetrate into the cage. The result is a steady drift of the spot of light from the electrometer, which, falling upon a moving photographic plate, gives a record of the current flowing (Method I). If the $\alpha$-activity of the preparation is zero, or even if it is very small, the preparation may be placed inside the cage, and it is still possible, by observation of the undisturbed portions of the line traced on the plate, to estimate the ionisation due to the $\beta$- and $\gamma$-rays (Method II). The table herewith gives the values obtained, the radioactivity of potassium being taken as unity.

|  | Na. | K. | Rb. | Cs. | U. |
|---|---|---|---|---|---|
| Method I .. | $<0{\cdot}002$ | 1 | 4·1 | 0 | 460 |
| Method II .. | $<0{\cdot}02$ | 1 | 7·6 | $<0{\cdot}03$ |  |

These results are for pure cæsium, the mineral polluxite, which contains no rubidium, having been employed. Interesting results were obtained with recently prepared lead, and with lead which had been exposed to the weather for 140 years The former showed about ten times the radioactivity of the latter. Observations on the relation between colour and activity in fluorspar, and on the penetrating radiations which are particularly strong at great heights, are also mentioned. H. N. A.

**2532.** *On the Absorption and Scattering of γ-Rays.* **N. Ahmad** and **E. C. Stoner.** (Roy. Soc., Proc. 106. pp. 8–19, July 1, 1924.)—In this paper the results obtained in Ahmad's previous paper on the absorption of penetrating γ-rays are discussed, with special reference to scattering. It is shown that the total apparent atomic absorption of γ-rays from RaB + C, filtered through 1 cm. of lead, is given by

$$\mu_a = 1{\cdot}9 \times 10^{-25}Z + 1{\cdot}6 \times 10^{-31}Z^4$$
$$= 0{\cdot}29\sigma_0 Z + 2{\cdot}29 \times 10^{-2}\lambda^3 Z^4$$

where Z is the atomic number of the element of which the absorber is made, $\sigma_0$ is the total scattering per electron on the classical theory, and λ is wave-length. The identification of the two terms in the expressions for $\mu_a$ with scattering and true absorption coefficients, based on analogy with X-ray experiments, is supported by the measurements of the scattered radiation; the term $1{\cdot}9 \times 10^{-25}Z$ is the scattering term, and the true absorption term is $\tau = 1{\cdot}6 \times 10^{-31}Z^4$. Writing this $\tau = b\lambda^3 Z^4$, and using for $b$ the mean X-ray value $2{\cdot}29 \times 10^{-2}$, the value $\lambda = 0{\cdot}019$ Å.U. is obtained. Unless a very improbable spectral energy distribution is assumed, the mean wave-length is certainly less than this. The extrapolation of the $\lambda^3$ law to these very short wave-lengths is only tentative, and much more experimental work is necessary. The wave-length is also estimated from the scattering term, using Compton's formula, the value being 0·0195 Å.U.; but the agreement of the values is partly fortuitous. The scattering per electron is approximately constant for the different absorbers, and between 20° and 80° is equal to $0{\cdot}14\sigma_0$. This constancy supports the view that the first term in the expression for $\mu_a$ corresponds to scattering absorption. Comparison with Compton's distribution formulæ shows qualitative agreement; but the formulæ lead to lower values for the total scattering absorption, and much lower values for the relative scattering, than those observed. H. N. A.

**2533.** *Absorption of Hard γ-Rays by Elements.* **N. Ahmad.** (Roy. Soc., Proc. 105. pp. 507–519, May, 1924.)—By means of a balance method the absorption of hard γ-rays from RaB + C has been measured with considerably greater accuracy than hitherto, and for a larger number of elements. The results indicate that the relations governing the apparent absorption are of the same type as for X-rays. The apparent atomic absorption can be represented by

$$\mu_A = 1{\cdot}68 \times 10^{-25}\,Z + 1{\cdot}60 \times 10^{-31}\,Z^4$$

Taking the first term to represent scattering absorption and the second photo-electric absorption, two estimates of the mean effective wave-length have been obtained (0·015 and 0·019 Å.U.) which are in fair agreement between themselves and with the indications of other work. A. B. W.

## HEAT.

**2534.** *Determination of the Thermal Coefficients of Expansion of Some Commercial Metals and Alloys.* **J. N. Friend** and **R. H. Vallance.** (Inst. of Metals, J. 31. 1. pp. 75–78; Disc., 78–79, 1924.)—A description is given of an apparatus for rapidly determining the coefficient of expansion of commercial metals and alloys in the form of bars of about 24 in. length. The apparatus consists essentially of a vertical steel tube, 27 in. in height and 3 in. internal diameter, the lower end of which is fixed to a heavy steel or cast-iron base. The bar to be tested rests on a quartz cylinder placed at the bottom of the tube. On the upper end of the bar rests a short quartz rod, the upper end of which supports the base of an Ames dial gauge. Readings of the dial are taken first when a current of water is sent through the tube and afterwards when steam is admitted. The dial gauge was calibrated with a spherometer. Results of tests on a number of metals and alloys are given. In the *Discussion* **D. Lewis** referred to the use of a thermionic valve circuit for measuring small changes in dimensions, and the President stated that the authors' results were, generally speaking, in agreement with those values already accepted for the alloys and metals they had tested.
W. C. S. P.

**2535.** *Thermal Conductivity of Some Industrial Alloys.* **H. M. Williams** and **V. W. Bihlman.** (Am. Inst. Mining Eng., Trans. 69. pp. 1065–1069, 1923.)—This method for determining thermal conductivity consists of heating one end of a bar electrically, measuring the amount of heat transmitted through the bar by a flow calorimeter fastened to the other end, and measuring the temperature gradient along the bar. In order to compensate for the loss of heat laterally the bar is surrounded by a steel pipe, electrically treated at the bottom and cooled at the top with a water-jacket. The test bar is supported at one end by a steel socket, upon which a 500-watt electrical heater is wound. Iron-constantan thermocouples are inserted in the test bar at two points, A and B. Two thermocouples are brazed into the bottom of the steel pipe. The annular space between the test bar and the steel pipe is filled with sil-o-cel packing. The coefficient of thermal conductivity is given by the formula $K = \frac{M \times (t_1 - t_2) \times l}{(T_1 - T_2) \times a}$, where K = quantity of heat in calories transmitted per second through a plate 1 cm. thick per sq. cm. of its surface when the difference of temperature between the two forces of the plate is 1° C.; M = rate of water flow in calorimeter in grams per second; $t_1$ and $t_2$ the temperatures respectively of the outgoing and incoming water of calorimeter, degrees C.; $T_1$ = temperature at point A, degrees C.; $T_2$ = temperature at point B, degrees C.; $l$ = distance between A and B, in cms.; and $a$ = cross-sectional area of bar, in sq. cm.
T. C. H.

**2536.** *Determination of Thermal Conductivity of Refractories.* **M. D. Hersey** and **E. W. Butzler.** (Washington Acad. Sci., J. 14. pp. 147–151, April, 1924.)—This paper contains a brief account of thermal conductivity work in progress at the Pittsburgh Experiment Station, U.S. Bureau of Mines, and a discussion of a suggested formula to correct for transverse heat leakage and departure from a steady state. In the apparatus used heat flows outward in both directions from a flat central heater, and it is caused to flow along paths perpendicular to the surfaces of the two samples tested by means of guard-heaters suitably regulated. The heat input is measured electrically, and the testing unit consists of three flat heaters and guard-rings wound with nichrome wire, two layers of brick under test (about 2 in. thick and 1 ft. square), and four thin metal plates with guard-rings. The apparatus includes about eighteen thermocouple circuits for measuring the various temperature drops.

The conductivity is computed from the equation $k = H/AG$, where H is the heat flow through area A, and G the corresponding temperature gradient. Usually G is taken to be the over-all gradient, $G_0$, *i.e.* $G_0 = t_1 - t_2/x$, where $x$ = thickness of the layer of brick comprised between the two isothermal planes $t_1$ and $t_2$. But then H must be taken as the corresponding heat flow $H_0$, averaged from input and outflow observation at the respective surfaces, except when there is no transverse heat leakage at all, and no accumulation of heat within the brick. On account of the high temperature of the cooler surface of the brick in the experiments another method has been used for applying the conductivity equation. For G the actual temperature gradient at the hot surface where H is observed is taken, and not the over-all gradient. This value of G cannot be directly measured, but it may be computed in terms of the over-all gradient $G_0$ by the relation $G = G_0(1 + dG/G_0)$, where the gradient correction is given by $dG/G_0 = 4\{(t - t_m)/(t_1 - t_2)\}$, where $t_1$ = temperature of junction near the hotter surface of the brick, $t_2$ = temperature near cooler surface, $t$ = mean temperature of the brick $(t_1 + t_2)/2$, and $t_m$ = observed temperature in the interior of the brick midway between $t_1$ and $t_2$. The results are given of six independent tests on Hytex hydraulic pressed building brick and on Central of Georgia firebrick. From these it appears that the true conductivity in c.g.s. units of Hytex brick is 0·0028 when $t_1$ = 155° C. and 0·0029 when $t_1$ = 175° C. or 260° C. For Georgia brick the true conductivity at $t_1$ = 290° C. is 0·0019, and for $t_1$ = 945° C. the true conductivity = 0·0027. J. J. S.

**2537.** *Application of the Interferometer to Measurements of the Thermal Dilatation of Ceramic Materials.* **G. E. Merritt.** (Bureau of Standards, Sci. Papers, No. 485, pp. 357-373, 1924.)—This paper describes the determination by an interferometer method of the thermal dilatation of a large number of ceramic materials over a temperature range up to about 1000° C. The specimens were in the form of tripods or pins 0·5 to 10 mm. long, separating two interferometer plates of fused quartz [see Abstract 1057 (1919)]. The under surface of the lower plate was unpolished and the upper surface of the upper plate was slightly inclined, so that the light reflected from this could be cut out of the field of view. The yellow radiation from He was used to produce the interference bands. The shift of the bands, with expansion of the separators, was observed with reference to a mark ruled on the lower surface of the upper quartz plate. The interferometer was situate at the centre of a vertical electrically heated furnace 30 cm. high, internal diameter 5 cm. The temperature was measured by a thermocouple in contact with the lower interferometer plate. The heating current was adjusted so that the rate of rise or fall of temperature was about 4° C. per minute. The materials investigated consisted of samples of glaze, terra-cotta, tile, porcelain, glass pots, and unburned clay. The results are shown in a number of curves coordinating change in length per cm. with temperature both for heating and cooling over the chosen range. With seasoned samples consistent results were obtained on repetition, showing that the method is particularly applicable for these materials where only small samples are usually available. The dilatation of the different materials differ greatly, and for any one material it varies with the part of the temperature scale. Permanent dimensional changes may also be brought about by heating. The data also explain the failure of certain glazes when used in combinations, for although the expansion curves of two materials may coincide at lower temperatures, they may diverge widely as the temperature rises. L. L.

**2538.** *Emissive Tests of Paints for Decreasing or Increasing Heat Radiation from Surfaces.* **W. W. Coblentz** and **C. W. Hughes.** (Bureau of Standards, Technol. Papers No. 254. pp. 171–187, Washington, 1924.)—An account is given of the results of experiments undertaken to find means of decreasing or increasing the rate of thermal radiation from heated surfaces. Data are given on the emissivity of sheet-iron, cotton-duck, roofing material, artificial leather, etc., covered with white paint, vitreous enamel, aluminium paint, etc. Duplicate samples of the material for test were selected, and the under (or upper) side of one sample was coated with aluminium or some other paint. These two samples were mounted in a holder and exposed to the sun. After the two samples were thoroughly heated, the intensity of the heat radiated from the underside of each one was measured by means of a sensitive thermopile. It was found that aluminium paint emits only 30 to 50 per cent. as much thermal radiation as the unpainted material, and as the white paint, vitreous glass, enamel, or other non-metallic coating. The data are useful in giving a means for reducing the heat radiated from the underside of roofs, tents, awnings, automobile tops, etc. A coating of aluminium paint applied to the top of an opaque canopy—for example, automobile top—reduces by 50 per cent. the heat radiated from the underside. A coat of aluminium paint applied to the underside of a cotton-duck tent-cloth shuts out 85 per cent. of the heat rays. The application of these data to house radiators is discussed. It is shown that, owing to the fact that house radiators are essentially convectors of heat, a gain of only 10 to 15 per cent. in heat dissipation into the room may be expected by covering the surface of the radiator with a paint which is free from flakes of metals, such as aluminium or bronze. W. C. S.

**2539.** *Apparatus for the Determination of the Heat of Evaporation of Liquids of High Boiling-Points.* **J. H. Awbery** and **E. Griffiths.** (Phys. Soc., Proc. 36. pp. 303–311; Disc., 311–312, June, 1924.)—The authors describe two new forms of electrical apparatus for determining the heat of evaporation of liquids of high boiling-point and discuss their relative merits. The fundamental principle of the first apparatus is the determination by condensation of the total heat of the vapour, and the subtraction from it of the total heat of the liquid to just below the boiling-point. The liquid was steadily boiled in a large vessel heated electrically and the vapour condensed into a silicon tube which was surrounded by a water-jacket, through which a stream of water passed at constant head. Copper-constantan couples arranged differentially gave the rise in temperature of the water, and a third couple indicated the temperature of the condensed liquid. The specific heat of the liquid was determined by the method of mixtures. Tests made on methyl-alcohol, water and aniline gave results within 1 per cent. This apparatus was also adopted to measure the heat required to evaporate a known mass of liquid by submerging a second heating coil in the liquid. The chief objection to this apparatus is the necessity for subsidiary experiments to determine the specific heat of the liquid or the heat required to maintain the calorimeter at the temperature of the boiling-point of the liquid. The second apparatus which is described gets over this difficulty. The liquid under test is contained in a small double-walled vessel connected to a condenser tube for collecting the condensed vapour. Surrounding this vessel is a thick walled metal enclosure wound with a heating coil, so that it can be maintained at the same temperature as the liquid. The liquid was heated by means of a submerged coil until the vapour was just slowly distilling over. By weighing carefully the amount vaporised per second at two known rates of energy input a value for the heat of vaporation (by difference) could be obtained with a high degree of accuracy. W. C. S. P.

**2540.** *The Heat of Vaporisation of Carbon.* **de Forcrand.** (Comptes Rendus, 178. pp. 1868–1871, June 2, 1924.)—The author refers to the high value of the heat of vaporisation of carbon which is obtained by substitution of the known boiling-point temperature in the formula of Trouton or the Nernst modification. He has previously proposed the alternative expression [Abstracts 1449 and 1450 (1913)]

$$L/T = 10\cdot 1 \log T - 1\cdot 5 - 0\cdot 009T + 0\cdot 0000026T^2$$

which fits well with observed values and covers a much wider range, *viz.* from the boiling-point of He 4·25° to that of Cu 2583° (abs.). Taking Violle's value for the boiling-point of C as 3800°, the latter expression gives for L 144,000 cals. per gm. molecule. Values proposed by various observers in recent years range from 140,000 to 287,000 cals. per gm. molecule. Using Kohn's recent determination of the boiling-point of C [Abstract 676 (1921)], *viz.* 4190° abs., L is 180,253 and L/T 43·52. Again, the vapour pressure data given by Kohn enable L to be deduced by aid of the Clapeyron equation. This method gives 163,500 cals. per gm. molecule. L. L.

**2541.** *The Measurement of Small Rates of Heat-production by Thermopile and Galvanometer.* **W. Hartree.** (Journ. Sci. Instruments, 1. pp. 265–272, June, 1924.)—This paper describes how the rate of heat-production in a living muscle on stimulation may be determined. The special thermopile employed consists of iron-constantan couples wound on a U-shaped frame of ivoride or glass. One set of junctions lies midway between the limbs of the U, the other set on the outside edges of the frame. The whole is coated with shellac varnish. The frame carries a pair of electrodes for excitation. The muscle lies on the control junctions, but is insulated from them by the thin coating of shellac. The thermopile and specimen are placed in a glass test-tube, which is surrounded by water contained in a vacuum vessel. The temperature of the water is maintained constant to 0·02° C. and may be raised above room-temperature by electric heating. A Broca or a Paschen galvanometer (period adjusted to about 3 sec.) is used in conjunction with the thermopile, and a time record of deflections is recorded photographically. To obtain the rate of heat production over any interval of time or the actual heat produced in some specified interval a time record of deflections is obtained for the living muscle under the prescribed stimulus. A control curve is then obtained when a known amount of heat is supplied for a known time to the dead muscle. The observed curve for the living muscle is then analysed into a set of curves of the type of the control curve. [Abstract 1464 (1921).]

**L. L.**

**2542.** *Repair of Leaky Calorimetric Resistance Thermometers.* **J. D. Davis and H. M. Cooper.** (Indust. and Engin. Chem. 16. p. 579, June, 1924.)—The access of moisture into the case enclosing the platinum resistance wire is prevented by soft-soldering the case—consisting of a thin, seamless silver tube—to a platinised glass tube, which is sealed to a fibre thermometer-head by means of Dekhotinsky cement. Solidified paraffin may be used to seal resistance thermometer coils without straining the wire and without increasing the thermometer lag appreciably. If desired, a small glass bulb containing phosphorus pentoxide may be used for keeping the case dry.

J. S. G. T.

**2543.** *Thermal Method for the Study of Gaseous Systems.* **G. Piccardi.** (Accad. Lincei, Atti, 33. i. pp. 287–290, April 13, 1924.)—Gaseous systems may be investigated by a thermal method which consists essentially in supplying the system with measured quantities of heat according to a known function of the time chosen arbitrarily, $Q = f(t)$, in observing the corresponding variations in temperature of the system itself or of constructing experimentally the function $\theta = \phi(t)$, and in constructing from these two functions a third, $\theta = \Phi(Q)$, which expresses the thermal phenomena taking place. The system is contained in a closed, rigid, invariable surface of negligible thermal capacity and constant thermal conductivity, the heat being introduced through a very small, totally enclosed surface. The surrounding medium is of such nature that the temperature variations which occur are rendered very small. The conformation of the surfaces is chosen so as to hinder as little as possible convective or other movements of the gas. The temperature is read at a large number of points of the system, and the mean value taken. It is shown that, for a perfect gas or in cases where it is possible, within certain temperature limits, to keep constant (1) the product of the mass of the system by the specific heat, and (2) a factor depending on the surface and on the capacity of the gas for convective heat transport, the $(\theta - T) : t$ and $(\theta - T) : K$ diagrams are completely calculable for any one gas. As yet it is not possible to ascertain the relation between these diagrams for different perfect gases under the same conditions.

T. H. P.

**2544.** *On Radiation Theory and Specific Heats by E. Császár.* **E. Schrödinger.** (Zeits. f. Physik, 25. 2. pp. 173–174, 1924.)—The present author criticises E. Császár's hypothesis, and points out that it is unlikely to prove in quantitative agreement with Debye's theory, or the experimental facts. [See Abstract 568 (1924).]

E. H. B.

**2545.** *The Influence of Indifferent Gases on the Saturation-Vapour Concentration of Liquids.* **F. Pollitzer** and **E. Strebel.** (Zeits. phys. Chem. 110. pp. 768–785, 1924.)—The change of the saturation vapour concentration of a liquid when compressed gases are present depends, in the absence of chemical effects, upon two different causes, *viz.* the pressure on the liquid and a dissolution effect of the compressed gas upon the vapour. The pressure effects an increase of the partial pressure over the liquid, which is independent of the nature of the pressing medium, and is solely a function of the pressure exerted upon the liquid. The second cause is a material property, and effects an increase in the vapour concentration. The change in the vapour concentration of water and carbonic acid by air, $N_2$, $H_2$ and $CO_2$, has been determined up to pressures of 200 kg./cm.$^2$ and at two temperatures, 323° and 343·2° abs., tables of data being included. A simple expression is derived for the calculation of the increase of vapour pressure by pressure, the saturation pressure being expressed as a function of the total pressure for the cases investigated. The difference between the calculated vapour concentrations corresponding to these pressures and the observed values is ascribed to the dissolution capacity of the compressed gas. This is small for water-vapour and $H_2$, appreciably greater for air, and very considerable for $CO_2$. From the change of water-vapour concentration with temperature in the presence of compressed $CO_2$ the heat of evaporation can be approximately evaluated. H. H. Ho.

**2546.** *The Internal Pressures of Solids.* **T. W. Richards.** (Am. Chem. Soc., J. 46. pp. 1419–1436, June, 1924.)—One of the objects of the investigation is the discovery of the hitherto unknown laws which determine the relation of the volume of liquids and solids to external pressures as well as to the great internal pressures which exist within them. The author recently suggested a hyperbolic interpolation equation, *viz.* $(p + P)(v - B_1) = k$, analogous to that of van der Waals, and showed that the change of volume of solids under pressure conforms to it in many cases. In this equation $p$ indicates external pressure, P is a function involving internal cohesive pressure, $v$ is the volume at given pressure $p$, $B_1$ is a fractional volume indirectly representing the resisting tendency or repulsive potential of an atom, and $k$ is a constant.

The equation is now modified so as to include the effect of temperature, being then written, $(p + P)(v - B_1) = k_1 + cT$, $k_1$ being independent of temperature. By differentiation it can be seen that $P = (1 - B_1)/\beta_0$, where $\beta_0$ is the coefficient of compressibility at $p = o$; and $c = \alpha_0(1 - B_1)/\beta_0$, $\alpha_0$ being the initial coefficient of expansion. The equation is found to agree extremely well with experiment for hard metals such as silver, platinum and tungsten. It may be written, $p + P = k_1/(v - B_1) + cT/(v - B_1)$, or $p + \pi = \pi_p + P_\theta$, $\pi$ and $\pi_p$, being assumed to be independent of temperature, but not independent of volume change. $\pi$ is the true cohesive pressure, $\pi_p$ is that part of the true distending pressure which is not due to heat. Probably each of these true pressures increases rapidly with diminishing volume. Making this assumption, the equation of state of a solid may be written as follows, $p + \pi_0(v_0/v_1)^m = (\pi_p)_0(v_0/v_1)^n + (P_\theta)v_1$. The last term is shown to be equal to $T\alpha/\beta$. As an example the following values are found to fit experimental values for silver, $p + 160{,}680(v_0/v_1)^{1\cdot 7} = 144{,}510(v_0/v_1)^{8\cdot 5} + (T\alpha/\beta)_{v_1}$. Evidence from other directions is given to show that the internal pressures thus deduced are probably near the truth, *e.g.* the internal pressure of silver would appear to have the value 145,000 megabars. A table is given of eighteen metals and their calculated internal pressures in megabars from cæsium 4000 to tungsten 632,000 megabars. **T. B.**

**2547.** *The Energy conveyed by a Flowing Gas and on the Thermal Phenomena discovered by Martin Knudsen.* **S. Weber.** (Zeits. f. Physik, 24. 5–6. pp. 269–284, 1924.)—The author first briefly discusses the investigations of N. Bohr on the energy carried by diffusing particles or electrons. Bohr obtains for the kinetic energy of a particle of a gas the expression $\frac{5}{2}k\mathrm{T}$, while $\frac{3}{2}k\mathrm{T}$ is the mean energy of the molecule. The difference between these quantities is accounted for by a flow of work $p\mathrm{V} = nk\mathrm{T}$. Bohr's result is also obtained by the author by simple gas kinetic theory considerations. If the molecule has rotational energy the expression becomes $\frac{5}{2}k\mathrm{T} \times \frac{3}{2}k\mathrm{T}(\mathrm{K} - 1)$. In the case of pure molecular streaming at constant temperature through a tube whose dimensions are small compared with the mean freepath Knudsen obtains the expression $\frac{4}{2}k \,.\, \mathrm{T}$ for the transported kinetic energy, or, if we include rotational energy, we have $\frac{4}{2} \,.\, k\mathrm{T} + \frac{3}{2}k\mathrm{T}(\mathrm{K} - 1)$. Knudsen (Report of first Solvay-Kongress, 1911) describes experiments in which hydrogen and atmospheric air were forced through a tube containing a long plug of glass wool, and in the stationary state a rise of temperature was observed at one end and a fall at the other end of the plug. The energy transported across two given end sections is $n\frac{5}{2}k\mathrm{T} + n\mathrm{K}$, while the energy $n \,.\, \frac{4}{2}k\mathrm{T} + n\mathrm{K}$ crosses any section of the plug. In this case energy $n \,.\, \frac{1}{2}k\mathrm{T}$ is liberated at one end and absorbed at the other. In hydrogen this Knudsen effect is opposite in sign to the Joule-Thomson effect. The Knudsen effect varies with the pressures $p_1$ and $p_2$, and several cases are briefly discussed. The results obtained are as given in Table I herewith :—

TABLE I.

| Hydrogen. | | | | Atmospheric Air. | | | |
|---|---|---|---|---|---|---|---|
| $p_1$ mm. | $p_2$ mm. | $\Delta t^0$. | $\Delta t^0_2$. | $p_1$ mm. | $p_2$ mm. | $\Delta t^0$. | $\Delta t^0_2$. |
| 2·6 | 0·06 | 0·06 | 0·03 | 2·5 | 0·04 | 0·03 | 0·02 |
| 5·7 | 0·12 | 0·11 | 0·06 | 9·0 | 0·07 | 0·07 | 0·04 |
| 84·8 | 1·5 | 0·69 | 0·67 | 94·6 | 1·10 | 0·18 | 0·20 |
| 125·0 | 3·6 | 0·73 | 0·74 | 161·7 | 2·34 | 0·12 | 0·12 |
| 159·0 | 4·5 | 0·75 | 0·79 | | | | |
| 182·0 | 11·0 | 0·62 | 0·68 | | | | |
| 341·0 | 21·0 | 0·20 | 0·20 | | | | |

$\Delta t^0$ = temperature difference between the two end sections.

$\Delta t^0_2$ = temperature difference between the last section and a thin plate in the gas beyond.

These results are now discussed in relation to the theory. A formula for the total energy received by a unit of area perpendicular to the flow of gas is obtained. This formula is used to compare the theoretical values with the experimental values obtained by Gaede [see Abstract 1763 (1913)] in his molecular pump, in which a small metal box with four separate sides is placed in a circular canal of square cross-section. The difference in temperature of the sides of the box is observed by the help of thermal junctions and compared with the calculated values. The results, which show good agreement considering the difficulties of the experiment, are given in Table II :—

TABLE II.

| Pressure $p$ dyne/cm.². | 2Δ$t$ Obs. | 2Δ$t$ Calc. | Pressure $p$ dyne/cm.². | 2Δ$t$ Obs. | 2Δ$t$ Calc. |
|---|---|---|---|---|---|
| 64·0 | 0·98 | [1·84] | 2·9 | 0·20 | 0·17 |
| 58·5 | 0·98 | [1·76] | 1·8 | 0·14 | 0·11 |
| 33·3 | 0·94 | 1·27 | 1·3 | 0·10 | 0·08 |
| 20·0 | 0·77 | 0·89 | 1·0 | 0·08 | 0·06 |
| 13·3 | 0·60 | 0·65 | 0·6 | 0·05 | 0·04 |
| 6·3 | 0·37 | 0·35 | 0·4 | 0·03 | 0·024 |

T.B.

**2548.** *Vapour Tension of Solid Carbon.* **J. J. van Laar.** (Comptes Rendus, 178. pp. 2250–2252, June 30, 1924.)—By means of Langmuir's method of evaporation *in vacuo* and the employment of the Knudsen-Langmuir formula, Wertenstein and Jedrzejewski [see Abstract 112 (1924)] obtained the relationship: $\log p_{\text{mm.}} = -47{,}000/T_e - 0\cdot75 \log T + 14\cdot87$. By converting $p$ to atmospheres and giving T in the variable term the value 4000° abs., this becomes: $\log_{10} p_{\text{atm.}} = -47{,}000/T_e + 9\cdot3$, whence $T_e$, the ebullition temperature, becomes 5050° abs. From a study of the coefficient of dilatation and the molecular attraction of graphite the author obtains $T_s$ (sublimation temperature) = 5010° abs., thus making it clear that the sublimation point is considerably above 4200° abs., the figure deduced from measurements by Lummer and by Kohn.

A. B. C. L.

**2549.** *The Chemical Constant of Hydrogen.* **W. H. van de S. Bakhuyzen.** (Zeits. phys. Chem. 111. 1–2. pp. 57–61, 1924.)—The chemical constant of hydrogen may be very accurately computed from the equilibrium solid-vapour and the experimental data now to hand. This is carried out in the paper, which is entirely mathematical, and amounts to − 1·112, the theoretical value being − 1·13.

H. H. Ho.

**2550.** *Critical Temperature in Condensation of Metal-vapours.* **J. Chariton** and **N. Semenoff.** (Zeits. f. Physik, 25. 4–6. pp. 287–291, 1924.)—Method of measurement. The critical temperature depends upon the nature of the surface as well as upon the vapour-density. The results are in accord with Langmuir's views as to the re-evaporation of imprisoned molecules.

A. D.

**2551.** *On Nernst's Derivation of the Clausius-Clapeyron Equation.* **R. Lorenz.** (Zeits. phys. Chem. 110. pp. 40–42, 1924.)—Nernst, in his celebrated manual of Physical Chemistry, derives the formula of Clausius-Clapeyron with the help of the Gibbs-Helmholtz equation of free energy. The following is the simple method employed: "We will now apply to the evaporation of 1 gramme molecule of a liquid in a vacuum the [Gibbs-Helmholtz] equation $A - V = T\frac{dA}{dT}$." [A = amount of diminution of free energy; V of total energy; T = absolute temperature.] "The volume which is at the disposal of the evaporating liquid we will choose as equal to the difference between the specific volumes of the saturated vapour V and of the liquid V′; then we have $A = p(V - V')$; $dA/dT = (V - V')dp/dT$; $V = p(V - V') - l$, and accordingly $l = T(V - V') dp/dT$, which is the Clausius-Clapeyron equation." An objection has been raised to this reasoning, in that if $A = pv$ ($v$ being put for $V - V'$), then $dA = pdv + vdp$, and not, as Nernst wrote, $dA = vdp$. The misunderstanding, however, is due to a want of knowledge of the formula of Gibbs-Helmholtz, which is deduced for constant volume. "The differential $dA/dT$ is so determined that no performance of work is associated with the heating of the system." The author therefore proposes that the equation should always be writen $A - V = T(\partial A/\partial T)_v$, in order to draw attention to the fact that it applies only to conditions of constant volume.

T. B.

**2552.** *Vector Representation in Thermodynamics.* **A. Lartigue.** (Comptes Rendus, 178. pp. 2169–2171, June 23, 1924.)—In the kinetic theory of gases the mean kinetic energy of translation is proportional to the absolute temperature $\tau$. The movement of translation may be assimilated to a radial vibration, in which case the mean kinetic energy, $\kappa\tau$, may be put on the real axis. The movement is propagated by a vibration until equilibrium is reached throughout the mass. On the imaginary axis lies the kinetic energy of rotation plus the potential energy of elastic deformation (internal energy, $\chi$, propagated inductively). Then the total energy $q = \sqrt{(\kappa\tau)^2 + \chi^2}$ and the specific heat $= \partial q/\partial\tau = \kappa^2\tau/q = \kappa \cos\phi$, with $\kappa$ constant (exterior work being neglected). When the specific heat increases with the temperature the angle $\phi$ falls off. This is the usual case; but in liquid mercury the converse happens. In liquid water the specific heat is sensibly constant; then $\phi$ is constant and $q = c\tau$. Make unit $c$ correspond to 1° C.; then $q$ measures the absolute temperature.

A. D.

**2553.** *The Probability of the Quantum States.* **E. Fermi.** (Zeits. f. Physik, 26. 1. pp. 54–56, 1924.)—When an atom is in different quantum states whose energies are $w_1, w_2 \ldots, w_r$, the probability that an atom may be in the $i$th state is usually solved by means of the hypothesis that the statistical weights of the states are equal, and so the probability relation is $p_i = Ce^{-w_i/kT}$, where C is a constant determined by the equation $\Sigma p_i = 1$. An important case arises, *e.g.* with an hydrogen atom, where $i$ states have energy, $w_i = -R/i^2$, making $p_i = Ce^{R/i^2kT}$, where $C = 1/\Sigma_i e^{R/i^2kT}$. Since, however, the sum diverges from C, the false result $C = O$ arises. This difficulty is overcome by the assumption that only such quantum states are possible whose radii are smaller than the average distance between the atoms. In the present mathematical paper the calculation of the equilibrium between the quantum states of the same atom is based on thermodynamic volume considerations, from which is concluded that quantum states seldom occur corresponding to a greater volume than that given by ordinary statistics. [See also Abstract 2129 (1924).]

H. H. Ho.

**2554.** *Absolute Entropy and the Chemical Constants of Polyatomic Gases.* **J. K. Syrkin.** (Zeits. f. Physik, 24. 5–6. pp. 355–365, 1924.)—This is a mathematical paper, in which the author attempts to obtain expressions for the entropy and chemical constant of polyatomic gases. A comparison is given between the results of calculation and experimental values. The order of magnitude of the results is the same. T. B.

**2555.** *The Quantum Theory of Monatomic Perfect Gases.* **G. Schay.** (Zeits. f. Physik, 25. 1. pp. 37–41, 1924.)—The author attempts to develop a theory of the degeneration (Entartung) of a gas which is free from the objection attaching to previous attempts. He starts with the statistical equation for the free energy :

$$F = -kT \log \sum e^{-E_n/kT} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

(see Planck, Wärmestrahlung, 5 Aufl., Gl. 433), in which $k$ = Boltzmann's constant, T = abs. temperature, $E_n$ = total energy of a gas in one of its permissible quantum states. The summation is to be extended to all these states. The problem is solved when this summation has been effected. The calculation is first made for a single gas atom, whose energy can be written :

$$\epsilon = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) + \epsilon_0 \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

The quantum conditions are introduced after Brody's method [see Abstract 946 (1922)]. Considering the gas in a cube whose edge is $a$, so that $a = V^{1/3}$, the phase integral becomes

$$2\int^{a} m\dot{x}\,dx = n'h, \text{ etc., where } \dot{x} = \frac{n'h}{2ma}, \text{ etc.}$$

Substituting in (2), $\epsilon = \dfrac{h^2}{8ma^2}(n'^2 + n''^2 + n'''^2) + \epsilon_0$

Putting $\dfrac{h^2}{8ma^2k} = \dfrac{h^2}{8mV^{2/3}k} = \theta$, we get for a single atom

$$e^{-\theta/T(n'^2 + n''^2 + n'''^2)}$$

$$e^{-\epsilon_0/kT} \cdot \sum_{n'=0}^{\infty} \sum_{n''=0}^{\infty} \sum_{n'''=0}^{\infty}$$

Since the three quantum numbers are independent of one another, this can be written :

$$e^{-\epsilon_0/kT}\left[\sum_{n=0}^{\infty} e^{-\theta/Tn^2}\right]^3$$

Extending this to the whole gas by Planck's method of considering the gas as a structure with 3N degrees of freedom we obtain ;

$$F = -NkT \log \left\{\frac{e}{N}\left[\sum_{n=0}^{\infty} e^{-\theta/Tn^2}\right]^3\right\} + N\epsilon_0 \quad \ldots\ldots\ldots \quad (3)$$

From this the author deduces entropy, energy, atomic heat and pressure, and finally that the region in which degeneration takes place is infinitely small, which does not agree with previous theories of degeneration. Essentially this requires that the gas atoms may be considered as mass-points, whose extent of mutual influence can be neglected. T. B.

## SOUND.

**2556.** *Dynamical Study of Vowel Sounds.* **I. B. Crandall** and **C. F. Sacia.** (Bell System Techn. J. 3. pp. 232–237, April, 1924.)—This paper gives the result of an analysis of spoken vowel sounds based on a set of accurate oscillographic records. The recording apparatus was designed to record the wave-forms of the different speech sounds practically free from distortion over the frequency range from 100 to 5000 cycles per second. A brief description of the apparatus is given at the end of the paper.

The thirteen vowel sounds investigated are *ū* (pool), *u* (put), *ō* (tone), *ô* (talk), *ŏ* (ton), *a*(father), *ar* (part), *ă* (tap), *ĕ* (ten), *ẽr* (pert), *ā* (tape), *ĭ* (tip), and *ē* (team). Eight records of each sound were taken, four by male and four by female speakers. The recording mechanism was so arranged that the whole of the sound from beginning to end was recorded in one continuous graph. In practice the average duration of these sounds was about 0·3 sec. Each record shows a sequence of growth and decay in amplitude somewhat as follows: *first*, a period of rapid growth in amplitude for about 0·04 sec., during which all components are quickly produced and rise nearly to maximum amplitude; *second*, a middle period, in which the general amplitude is nearly constant, but with varying phase relations between the different components and lasting about 0·17 sec.; and *finally*, a period of gradual decay lasting about 0·09 sec., in which all the components disappear. The essential point of the method of analysis used is that the whole record, from start to finish, is taken as the unit for analysis, and the data obtained are therefore the average characteristics of the sounds throughout their duration.

It is usual to exhibit the properties of a vowel sound in a spectrum diagram showing the amplitude of the component vibrations as a function of their pitches or frequencies. For each vowel sound there are, in addition to fundamental tones, certain characteristic regions of resonance which may be at high or low frequencies. It would be possible from the results of this analysis to present the sound spectra of each vowel showing the relative amplitudes for the different frequencies as present in the original air vibrations, but this treatment has been modified to take into account the relative importance of the various pitches in hearing. Using the data available on the relative sensitivity of the ear at different frequencies, the acoustic amplitude at each frequency has been multiplied by the corresponding ear-sensitivity factor, and the products so obtained are taken to be the effective amplitude-frequency relations which are characteristic of the sounds in question. The data from the four male records furnish one spectrum and those from the four female records another, each shown separately on the diagram. This diagram shows the essential dynamical properties of these thirteen vowel sounds. The first six vowels (as in p*oo*l, p*u*t, t*o*ne, t*a*lk, t*o*n, f*a*ther) include those usually designated as having single regions of resonance. Progressing through this sequence from pool to father, this region of resonance rises in average frequency and becomes narrower in range. There is also, at least with male voices, a somewhat scattered and less well-defined high-frequency range of resonance, perhaps not essential in speech, but more highly developed in well-trained singing voices. The sequence from *father* to the end of the diagram (*team*) includes most of those sounds known to have two characteristic regions of resonance. The main region of resonance is seen from the diagram to divide here into two parts, which gradually recede from each other as we follow the diagram down.

Viewing the diagram as a whole, it is important to consider not only the location of the resonant ranges, but also their extent and their *relative separation* from other resonant ranges, in order to arrive at the essential characteristics of the vowel sound. In other words, the individual vowel characteristic depends *not only on the absolute* pitch, but on the *relative* pitches, in case there is *more than one region* of resonance.

E. H. B.

**2557.** *The Frequency Components of Speech and Music.* **K. W. Wagner.** (Elekt. Zeits. 45. pp. 451–456, May 8, 1924. From the Telegraphentechn. Reichsamt.)—The author describes the work of D. C. Miller (Science of Musical Sounds) and C. Stumpf on the frequency components of speech and musical sounds, and confirms their results by means of filter circuits. For instance, Miller finds that the vowel U is characterised by a frequency of about 320, and the vowel I by two frequencies of about 310 and 3000. On sounding the vowel I into a microphone and passing the resulting current through a filter which cuts off frequencies above 2000, the author finds that the vowel sound heard in the receiver is U instead of I. Similarly, when the overtones from a violin are cut off by a filter circuit, the sound received leads one to believe that a flute is being played.

E. M.

**2558.** *Sound Velocity and Height.* **W. J. Humphreys.** (Frank. Inst., J. 197. pp. 821–824, June, 1924.)—The apparent lowness of the velocity of sound over large distances may be due to travel of the sound largely in the upper air. Using the closely known average values of pressure and density at different heights over north-western Europe, the values of the velocity of sound at these heights are computed. The velocity decrease with height is of such an order as to make the above explanation possible.

G. A. S.

**2559.** *Use of Condenser Microphone to Depict Sounds.* **F. Trendelenburg.** (Zeits. techn. Physik, 5. 6. pp. 236–250, 1924.)—After discussing methods previously employed in depicting vowel sounds, etc., a method is described in which a condenser microphone designed by H. Riegger is used for obtaining curves showing the wave-form of various sounds. The construction of the microphone is as follows: A piece of thin aluminium foil (A) between two very thin silk membranes is stretched 0·1 mm. behind a metal plate (P), in which slits are cut. A stiff back-plate 2 mm. behind the foil completes the receiver. It is shown that in the region of speech frequencies the amplitude of the metal foil A is proportional to the pressure amplitude of the sound-waves reaching it through the slits in the plate P. The plate P and the foil A are used as the two plates of a condenser, which is introduced in a high-frequency transmitting circuit, so as to obtain low-frequency modulation of the carrier waves. The curve form of the modulations is then photographed by means of an oscillograph or similar instrument, using suitable high-frequency amplifiers and rectification. Photographs are given showing the wave-forms obtained for all the vowels and for the sibilant *sch*, and the technical application of the results is discussed. A. W.

**2560.** *Helmholtz Theories of Struck String. Part II. Experimental.* **W. H. George.** (Phil. Mag. 48. pp. 34–43, July, 1924.)—In a previous paper [Abstract 1527 (1924)] the Helmholtz theories of the struck string were considered and, in order to subject the second theory to quantitative experimental test, expressions were there deduced for quantities whose magnitude could be determined from a displacement-time curve of the struck point of the string. In the present paper the apparatus used for obtaining experimentally the required displacement-time curves photographically is described together with reproductions of the results obtained. These results when summarised and compared with those which would follow from Helmholtz's second theory show large discrepancies between experiment and theory when a light hammer (hammer was 0·267 that of string) is used, but when the ratio of hammer mass to string mass is 1·7 experiment and theory nearly agree. When the ratio much exceeds this value there are discrepancies again. Where it is possible to make comparisons between experiments and Kaufmann's theory the latter shows only small discrepancies. E. H. B.

**2561.** *Delemer and Lamb Theories of Struck String.* **W. H. George.** (Phil. Mag. 48. pp. 48–55, July, 1924.)—In the study of the struck string the pressure-time laws of the impact is of considerable interest, since, if it be completely known, then the intensities of the fundamental tone and partials of the freely vibrating string, and consequently the resulting tone-quality, can be determined by the analytical method. Three forms of the pressure-time law have been assumed by Helmholtz, by Delemer, and by Lamb respectively. [See Abstract 1527 (1924) and preceding Abstract.] In the present paper theoretical expressions are derived on Delemer's and Lamb's theories for quantities whose magnitude can be determined from photographically-obtained displacement-time curves for the struck point of the string, and the theoretical results are then compared with those found by experiment.

On Delemer's theory the pressure of the hammer is assumed to be *constant* during the time of impact. On Lamb's theory the force on the hammer is proportional $I\tau/(t^2 + \tau^2)$, where I is the time integral of the force, $\tau$ is duration of impact, and $t$ the time reckoned from beginning of impact.

The results of the experiments and their comparisons with the theories not only of Delemer and of Lamb, but those of Helmholtz and Kaufmann are exhibited in tables and in graphs. It thus emerges that the Kaufmann theory is much the nearest to the experiments. The Helmholtz and the Delemer theories err by giving too large a displacement, and the Lamb theory by giving one which is too small. E. H. B.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

**2562.** *Electromagnetic Field of an Electron in Movement.* **F. J. de Wiśniewski.** (Arch. des Sciences, 6. pp. 211–214, May–June, 1924.)—The author here corrects an error in calculation in the third part of a previous paper with the same title. [See Abstract 584 (1924).]

G. W. de T.

**2563.** *The Electromagnetic Equations as Basis of Einstein's Quadratic Form.* **R. Hargreaves.** (Cambridge Phil. Soc., Proc. 22. pp. 138–162, May, 1924.)—The ground work of this paper, which is wholly mathematical, is a general transformation of Maxwell's equations, effected, not by direct treatment of the differential equations, but by use of the electromagnetic and magneto-electric integral forms introduced in an earlier paper [Cambridge Phil. Trans. 21. 1908]. These two forms originally contained, respectively, the two triads X and B of Maxwell's equations, both of which were immediately expressible in terms of potentials; but whereas one group of Maxwell's equations is then satisfied identically, in the other the singularities are attached to separate potentials only by the interposition of an integral form of the third order. In the present paper, therefore, the two original integral forms are generalised, containing four triads, two of which represent Maxwell's X and B for free ether, while for a dielectric, specific constants connect the other two variables with the values of X and B. It is then found that, subject to one proviso, this secures the expression of the singularities by derivatives of the separate contravariant potentials, formed by variation. The proviso makes no less a demand than that the analytical conditions postulated by Einstein for the existence and determination of a gravitational form must be satisfied. The author's conclusion then is that "If we extend the type of electromagnetic equations in coordination with a quadratic form, and apply the methods found for the reducible curve, I take it to be a primary office of those limitations that they satisfy a reasonable demand of electromagnetic theory." That is to say, Maxwell's equations are to be so altered as to fit into Einstein's mathematical formula. G. W. de T.

## DISCHARGE AND OSCILLATIONS.

**2564.** *Ionising Tension of Positive Ions.* **J. Franck.** (Zeits. f. Physik, 25. 4–6. pp. 312–316, 1924.)—Calculations of the ionising tension of positive ions, built upon the validity of the energy and impulse theorem, show that positive atom-ions can ionise atoms of the same gas by suitable collisions when their kinetic energy amounts to at least one and a half times the ionising work. Such a process is of extremely rare occurrence. By collisions of atom-ions with atoms of another kind of gas, in addition to the kinetic energy, the difference of the work of ionising the colliding and struck atom can be transformed into ionisation. It is pointed out that the described process of ionisation and charging applies only for collisions of slowly moving ions; with the rapidly moving canal-rays, and still more with α-rays, the simple collision law naturally fails. A. E. G.

**2565.** *Ionisation, Excitation, and Dissociation of Gases.* **A. L. Hughes.** (Phil. Mag. 48. pp. 56–64, July, 1924.)—The purpose of this communication is to call attention to a number of researches recently published on effects involving ionisation, excitation, and dissociation in gases, to point out apparent difficulties in correlation, and to draw certain tentative conclusions. The investigations referred to deal almost entirely with hydrogen. The ionising and radiating potentials of hydrogen have been studied by numerous physicists. The results of Franck, Knipping and Krüger [see Abstract 648 (1920)] stand out as being most directly accounted for by theory. Similar results have been obtained by Olmstead and by Horton and Davies [see Abstract 313 (1924)], except that the corresponding voltages are about a volt lower. In all these investigations the interpretation of any particular critical potential as a molecular effect, or as an atomic effect accompanied by dissociation, is not the result of direct experimental demonstration, but is inferred from the suggestions of theory and the hints given by spectroscopic evidence. The application of positive-ray analysis by Smyth to ionising potential experiments introduced a direct experimental demonstration of the nature of the positive ions produced at different ionising potentials. A discussion of Smyth's investigation of ion (*i.e.* whether atomic or molecular) following ionisation by electron impact and of the author's investigation on the dissociation of hydrogen by electron impacts, points to the conclusion that dissociation of hydrogen molecules by electron impacts is accompanied much more often by excitation of the atoms than by ionisation. That dissociation of hydrogen molecules is frequently accompanied by excitation of the atoms receives strong support from an investigation of the distribution of energy in the spectrum of hydrogen as a function of the energy of impact of the electron. Attention is drawn to the view that the fundamentally important variable in determining the character of a spectrum and, in particular, the distribution of intensity in it, is the energy of impact of the election on the molecule.

A. E. G.

**2566.** *A New Photoelectric and Ionisation Effect. The Discharge in a Neon Lamp.* **U. A. Oschwald** and **A. G. Tarrant.** (Phys. Soc., Proc. 36. pp. 241–249; Disc., 249–252, June, 1924.)—For the discharge in a neon lamp to start a certain minimum voltage is necessary. This voltage is found to be affected very considerably by light or other ionising agents external to the lamp. Very similar effects are produced by all the source of light tried, they are: (1) A 10-amp. carbon arc, with condenser, at a distance of 2 metres; (2) a 20-watt tungsten vacuum lamp at 1 metre; (3) a 16-c.p. carbon lamp at 1 metre; (4) a match flame at 1 metre. All the above sources of light produced a drop in the starting voltage from 180 to about 162 to 164 volts. The light effect is investigated in some detail, and it is found that it is produced by illumination of any intensity above a very low value (0·01 foot-candle producing an appreciable effect), that it is caused by rays of a broad waveband in the visible spectrum, with a maximum effect in the orange, and that the seat of the effect is located on the surface of both the metal electrodes, irrespective of polarity. It is shown that the light effect ceases instantly in the dark when the light is shut off. A similar effect, but one whose mechanism is believed to be different, is found to be caused by rays from uranium oxide and from an X-ray tube. In the latter case it was extremely well marked, so that it is possible to detect by this means

X-rays from a very feeble tube at a distance of 90 ft. Certain practical applications of this effect are suggested. In an addendum it is stated that more recently manufactured lamps show no trace of the effect at all. *Discussion*: **J. W. Ryde** put forward the hypothesis that the effect of light seems to be connected with the presence of hydrogen in the gas and of certain films on the electrodes. Whether the effect is due directly to $H_2$ or to the surface films associated with it and water vapour, it is too early to say. The evidence at present, however, points to the latter conclusion. He also suggests that the manufacturers now know more about the effects of impurities, and greater care is taken to eliminate them, hence lamps of recent manufacture do not show the effect. [See next Abstracts.] A. E. G.

**2567.** *Certain Properties of the "Osglim" Neon-filled Lamp.* **J. H. Shaxby and J. G. Evans.** (Phys. Soc., Proc. 36. pp. 253–261; Disc., 278–280, June, 1924.)—The "Osglim" lamp, consisting of pure iron electrodes 2 or 3 mm. apart, in an atmosphere of neon (with small quantities of helium, hydrogen, mercury vapour and other gases) is essentially a low-vacuum gaseous discharge tube; the study of the lamp which forms the greater part of this paper shows that the peculiarities of its voltage-current characteristic are explicable by the known facts as to the electric discharge in gases at the pressure, about 10 mm. of Hg, to which these lamps are exhausted. The characteristic curves of the lamps have been described for a range of about 150 to 200 volts by Pearson and Anson, and by Macgregor-Morris, Dowty and Privett [see Abstract 410B (1923)]. These curves have now been redetermined and the range extended down to the smallest currents which will maintain a discharge through the lamp. The subject is here dealt with under the following sections: (1) Determination of the volt-ampere characteristic; (2) sparking potential; (3) minimum potential; (4) form of the characteristic; (5) the negative part of the characteristic; (6) alternating current phenomena; (7) measurement of a.c. frequencies. It is concluded as the result of the experiments that the characteristic (voltage and current) curve of the "Osglim" neon-filled lamp illustrates many of the properties of the discharge of electricity through rarefied gases. The identity of the sparking potential with that necessary to produce a min. current through the gas, pointed out by Townsend, is clearly confirmed. Part of the characteristic is negative, and this results in the lamp discharge becoming intermittent on a direct current supply over a certain range of external resistance, independently of any external condenser in the circuit. This tendency to a negative characteristic appears, whatever the current through the lamp, when any change is made in the circuit, and this produces instability at the moment of switching on the lamp, and in the case of a.c. supply causes an intermittent discharge during that part of the cycle, when, so far as the supplied volts are concerned, a continuous glow might be expected. Illustrations are given of the use of the lamp as an indicator in a commutator method of measuring the frequency of alternating currents. [See preceding Abstract.] A. E. G.

**2568.** *Some Electrical Properties of the Neon Lamp.* **U. A. Oschwald and A. G. Tarrant.** (Phys. Soc., Proc. 36. pp. 262–268; Disc., 276–280, June, 1924.)—The points dealt with in this paper are: (1) The experimental determination of the wave form of the "oscillations" of a neon lamp.

By means of a special accurately timed switch, a neon lamp is thrown into the "oscillating" state, and its voltage measured after any predetermined interval, from 0·005 to 0·5 secs. From results the voltage time curve is plotted and is found to be in very close agreement with theory. (2) The maximum frequency obtainable with an "oscillating" neon lamp. The lamp is made to oscillate at its highest possible frequency, which is measured by a tuned circuit. Measured frequencies do not agree well in this case with theory, but a maximum frequency of about 95,000 is observed. (3) The maximum interval of interruption for a "steady" neon lamp. A lamp is run at such a voltage that if the discharge is interrupted for any considerable time it will not restart, the voltage being below the minimum starting voltage for the lamp. The circuit is interrupted by a special high-speed interrupter for separate single intervals down to $5 \times 10^{-5}$ secs. In no case did the discharge restart, showing an ionisation persistence of less than this interval. [See preceding Abstracts.] A. E. G.

**2569.** *A Critical Resistance for Flashing of the Low-Voltage Neon Discharge Tube.* **J. Taylor** and **W. Clarkson.** (Phys. Soc., Proc. 36. pp. 269–278; Disc., 278–280, June, 1924.)—This paper deals with the resistance conditions necessary for the maintenance of the well-known phenomenon of "flashing" of the neon discharge tube. If a high-resistance is connected in series with a neon lamp, having a capacity shunted across its electrodes, the continuity of the current through the lamp is interrupted, and it "flashes" at regular intervals of time. The time between the flashes is equal to the time required for the condenser to charge up added to the time necessary for it to discharge through the lamp. It is shown theoretically that there is a critical value $R_c$, for the resistance in series with the neon tube, below which no flashes can be obtained. This critical value of the resistance is expressed by the relation $Rc = (E - V_B)/k(V_B - V_A)$, where E is the charging voltage, $V_B$ the lower critical voltage, $V_A$ the kathode fall of potential (approximately), and $k$ the conductance of the discharge tube. Full details are given of experimental methods, and the results obtained from them using the "Osglim" lamp are found to confirm the above relation exactly. [See preceding Abstracts.] A. E. G.

**2570.** *The Ionisation of Cæsium Vapour and the Mobility of Electrons in the Bunsen Flame.* **B. T. Barnes.** (Phys. Rev. 23. pp. 178–188, Feb., 1924.)—A flame with a cross-section of 2 by 4 cm. was formed above rows of quartz tubes fed with air and gas into which dilute Cs salt solution was automatically sprayed. The *conductivity c* as a function of the concentration K of the solution was determined from the potential gradient, measured by means of Pt test wires and from the current to the central disc of a guarded anode. The concentration of vapour *m* in the flame as a function of K was computed from the velocity of the flame measured stroboscopically and from the amount of solution sprayed. The black body temperature was measured by introducing NaCl vapour and matching the emission against that of a tungsten filament for the same wave-length, assuming the emission to be merely a temperature effect. These results permitted of the calculation of Saha's equilibrium constant K (the constant for the equilibrium between neutral atoms, positively charged atoms and electrons), and the comparison of this with the value given by Saha's equation, for it is shown that

$mc/(c^2 - 1) = A + Bc$, where A and B are constants, and that $K = (B^2/A)RT$ where R is the gas constant. The value of K was inserted in Saha's equation, and it was solved for T. The two best values agree within 25° with the observed temperatures—a result which tends to confirm Saha's theory. The mobility of electrons in the flame was also computed from the measurements made, the equation being $k_e = c_0'/BNe$, where $c_0'$ is conductivity of the unsalted flame and N is the Avogadro constant. The results range from 75 to 207 m./sec. for 1 volt/cm., but the last two values, 75 and 82, were obtained under more constant conditions and are considered more trustworthy. J. J. S.

**2571.** *Analysis of Resonance Curves Observed in Potassium Vapour.* **R. C. Williamson.** (Phys. Rev. 24. pp. 134–142, Aug., 1924.)—A previous discovery of thermionic emission from copper at temperatures above 150° C. in the presence of potassium vapour, made it possible to secure resonance curves under simplified conditions, with plane parallel electrodes and an equipotential source of electrons with low thermal energies. The curves obtained show up to nine peaks, proving the presence of electrons that had made at least eight resonance collisions. Resonance potential for potassium, obtained from the positions of the maxima and minima of the curves, comes out 1·63 volts, within 2 per cent. of the value 1·608 from spectral series. An attempt is made to account for the shape of the curves, assuming the chance of resonance collision independent of the velocity and taking account of the transverse components of velocity resulting from non-resonance collisions, by means of an arbitrary function. This theoretical analysis of the curves gives values of the ratio of the chance of a resonance collision to the kinetic theory chance of collision (calculated from data for argon) of about ten, which indicates that the assumed kinetic theory mean free path is too large and also that the probability of resonance occurring upon collision is high. AUTHOR.

**2572.** *Photography of the Electric Discharge with the Positive Column in Motion.* **G. Valle.** (N. Cimento, 1. pp. 99–106, Jan.–April, 1924.)—The author has previously published some results of an experimental research undertaken to determine the relation existing among the sparks constituting the luminous mass in motion studied by Righi and the form of the discharge with stratified positive column which is observed at very low pressures. The present paper is to put on record the results of that research, with some photographs of the phenomena observed. A detailed description of the apparatus used is given, and a diagram of it is also shown. After tabulating the results which it is concluded can be drawn from the observations made, a number of photographs are described which show appearances obtained with discharges in tubes at pressures varying from 6 mm. to normal atmospheric pressure. A. E. G.

**2573.** *The Phenomenon of Emission of Anode Rays.* **M. Morand.** (J. de Physique et le Radium, 5. pp. 105–112, April, 1924.)—In 1906 Gehrcke and Reichenheim observed in the vacuum of a discharge tube a bundle of rays of a new kind emitted under certain conditions by an anode composed of metallic salts. Many physicists have remarked on the irregularity of the behaviour of the phenomenon, and the present experiments are an attempt to obtain a more pure phenomenon and at the same time a more regular and more durable emission. Without actually solving the problem, the experiments described, however, establish a new technique much more certain than those which have preceded it. The circumstances of certain emissions are, besides, determined in a sufficiently clear manner to be able to establish with some solidity the general theory of the phenomenon. The experimental arrangement is described in detail with the aid of diagrams. An attempt is made to determine the best relative positions to give anode and kathode, as well as their form, and to find the best degree of heating of the anode. The chief salts employed are those of lithium, the chloride, bromide and iodide. In an addendum it is stated that experiments have since been carried out with improved apparatus, and that these confirm those previously obtained and here described. It is also found in these later experiments that a vacuum of the order $10^{-4}$ mm. is necessary in the tube. For a certain temperature of the salt placed upon the point of the anode the emission only commences when the field attains a certain value. When the tension is increased between the anode and kathode, the phenomenon occurs suddenly for a certain min. p.d. and afterwards rapidly increases. A further account of these experiments will shortly be published. A. E. G.

**2574.** *The Luminosity of Vacuum Tubes in the Neighbourhood of a Sparking Coil.* **D. B. Deodhar.** (Zeits. f. Physik, 25. 4–6. pp. 338–341, 1924.)—A study of the behaviour of vacuum tubes, with and without electrodes, in different positions with respect to an induction coil in action. The luminous effects are due to variations in the electromagnetic potential in the space round the coil. The intensity of the effect increases as the pressure diminishes from 40 mm. to 0·01 mm., and decreases to zero as the pressure is further lowered. Apparently the molecules of the gas are ionised under the influence of the field. The action of a bar magnet on these discharges indicates that they are due to moving molecules electrically charged. H. N. A.

**2575.** *Sound Measurements in Arc Lights with High-Frequency Currents.* **A. Hagenbach** and **M. Wehrli.** (Zeits. f. Physik, 26. 1. pp. 23–39, 1924.)—The authors have recently published [see Abstract 957 (1924)] a method of determining the high-frequency, alternating-current resistance in an arc light. By this means it was possible to calculate its counter e.m.f. It was then found that this counter e.m.f. is situated in or near the electrodes. In the present paper the distribution of resistance in the arc is investigated, and at the same time the counter e.m.f. at the anode and at the kathode is determined. The results obtained by Duddell are confirmed.

A diagram of the experimental arrangements is given, as are also the tabulated results obtained with different kinds of carbon electrodes. The result obtained in the previous experiments, that the counter e.m.f. in the gas column vanishes, is confirmed. A connection is found to exist between the resistance in the gas column and the spectral light emission. The counter e.m.f. at the anode mounts with increasing crater temperature; at the same time the anode fall increases. A. E. G.

**2576.** *The Natural Electric and Magnetic Oscillation of Dielectric and Conducting Spheres.* **A. Schaefer** and **K. Wilmsen.** (Zeits. f. Physik, 24. 5–6. pp. 345–354, 1924.)—Using the method of Barkhausen and Kurz short undamped electromagnetic waves are produced and the diffraction by dielectric and conducting spheres is investigated. Apart from insignificant discrepancies due to departure of the apparatus from ideal conditions the positions found for the natural oscillations are in agreement with theory. G. A. S.

**2577.** *Electromagnetic Waves in Moving Continuous Media.* **L. Roy.** (Comptes Rendus, 179. pp. 103–105, July 16, 1924.)—The analysis introduced in a previous paper [see Abstract 2306 (1924)] is extended and a general formula is obtained which accounts easily for astronomic aberration but not for the Fizeau effect. A. B. C. L.

**2578.** *Oscillating Circuits with Iron-Cored Inductances.* **L. Casper, K. Hubmann and J. Zenneck.** (Zeits. f. Hochfrequenztechnik, 23. 4–5. pp. 63–77, 1924.)—In a previous theoretical research by Schunck and Zenneck [see Abstract 954 (1922)] on the forced oscillations in a circuit containing ohmic resistance, capacity, iron-free inductance, and also a coil with a ring core, certain results are obtained; the present paper gives the results of an experimental investigation of the same question. An a.c. generator of 5-kw. output at a frequency of about 500 is connected in series with a condenser, an iron-free inductance, ring magnet, rheostat, and hot-wire ammeter; a hot-wire voltmeter gives the voltage across the terminals. Current-voltage characteristic curves are taken (*a*) with purely a.c. magnetisation of the ring, and (*b*) with added d.c. magnetisation. A peculiarity of the measurements consisted in a sudden increase of current as the voltage increased through a certain critical value, and a similar sudden decrease with diminishing voltage, giving a graph which encloses an area. The sudden change is called the "Kipp" effect, and in testing the effect caused by change of resistance, it was found that the Kipp effect diminished as the resistance increased, ultimately disappearing at a certain critical resistance. Resonance curves, *i.e.* current-frequency curves are given which agree in form with those of Martienssen (1910) and Barkhausen and Lichte (1920). With increasing frequency, the current rises steadily to a maximum, then drops first suddenly then slowly as the frequency is increased. When the voltage is given a higher value, the current maximum is greater and takes place at a higher frequency than before; the Kipp effect is also present. The resonance curves thus differ from those for iron-free circuits in the respects that they are unsymmetrical and the resonance frequency increases with the voltage. When d.c. magnetisation is added to the a.c. magnetisation of the ring, changes take place in the form of the characteristic curves. With a certain magnetising current (d.c.) the volt-current (a.c.) graph has two resonance points and no Kipp effect; with weaker d.c., the Kipp effect is present near the higher resonance point, and with stronger d.c. it appears near the lower point of resonance. When alternating current is plotted against direct current, three types of graph are distinguished according as they contain no Kipp effect or one or two. With the given arrangement and a terminal voltage of 60, a variation of the direct current of 5·8 amps. by 0·4 amp. caused a change in the effective alternating current of 7·3 amps. The effect of resistance change is again studied; also resonance curves are given and finally the current waveform is determined by means of a Braun tube. With purely a.c. magnetisation, the current wave is composed chiefly of a fundamental and its third harmonic; as the result of added d.c. magnetisation, the second harmonic appears. G. E. A.

**2579.** *Surges in Back-Coupled Circuits. III.* **K. Heegner.** (Zeits. f. Physik, 24. 5–6. pp. 366–392, 1924.)—Continuing previous work [Abstract 1154B (1923)], the author proceeds to develop a theory of coupled circuits, making use of rational functions of complex argument, and then applies the theory to the case of three circuits with primary back-coupling. It is shown that three frequencies are possible, and a discussion is given of the case of principal interest in which the two outer frequencies have the same amplitude, and the frequency difference between them and the central frequency is the same. A. W.

## ELECTRICAL PROPERTIES AND INSTRUMENTS

**2580.** *Photoelectric Effect.* **F. Kirchner.** (Phys. Zeits. 25. pp. 303–306, June 15, 1924.)—The limiting wave-length, the maximum energy of the expelled electrons, and the position of the maximum photoelectric effect can all be numerically deduced from the spectroscopically-known terms for the energy of the atom, provided we admit that at the outer surface of the metal there are atoms electrically free (atoms of metal-vapour). A. D.

**2581.** *Effect of the Superficial Layer on the Electrical Conductivity of Solid Salts.* **P. Vaillant.** (J. de Physique et le Radium, 5. pp. 84–91, March, 1924.)—The study of the effects of temperature variation on the electrical conductivity of a number of solid salts, as recorded in a previous paper [see Abstract 1700 (1922)], is extended over a wider range and under more precisely determined experimental conditions. It is found that the conductivity of the salts studied is in large measure superficial and due to the formation, according to the hygrometric state of the surrounding air, of an ionised peripheral layer. A. B. C. L.

**2582.** *Electrical Conductivity and the Bohr Atomic Theory.* **O. Feussner.** (Zeits. f. Physik, 25. 3. pp. 215–219, 1924.)—The author has constructed a table, completing that of Bohr, giving the most probable types of electronic orbits for a number of additional elements. The following cases are of interest :—

| $n_k$. | | $1_1$ | $2_1$ | $2_2$ | $3_1$ | $3_2$ | $3_3$ | $4_1$ | $4_2$, etc. |
|---|---|---|---|---|---|---|---|---|---|
| 18 | A | 2 | 4 | 4 | 4 | 4 | – | – | – |
| 19 | K | 2 | 4 | 4 | 4 | 4 | – | 1 | – |
| 22 | Ti | 2 | 4 | 4 | 4 | 4 | 2 | (2) | – |
| 23 | V | 2 | 4 | 4 | 4 | 4 | 4 | 1 | – |
| 24 | Cr | 2 | 4 | 4 | 4 | 4 | 4 | 2 | – |
| 25 | Mn | 2 | 4 | 4 | 6 | 4 | 4 | 1 | – |
| 26 | Fe | 2 | 4 | 4 | 6 | 6 | 4 | – | – |
| 27 | Co | 2 | 4 | 4 | 6 | 6 | 4 | 1 | – |
| 28 | Ni | 2 | 4 | 4 | 6 | 6 | 6 | – | – |
| 29 | Cu | 2 | 4 | 4 | 6 | 6 | 6 | 1 | – |

In the alkali metals, of which potassium in the above table is a typical example, the previous element in the table is a rare gas. It will be seen that the orbit groups $3_1$ and $3_2$ are temporarily filled up, and the last electron occupies a new orbit. A curve showing the variation of atomic electrical conductivity of the elements with atomic numbers has maxima for the alkali metals. The table shows that the orbit arrangement of Ni is quite similar to that of an inert gas, and that the succeeding element, copper, has the same arrangement, with the addition of one electron in an outer orbit $4_1$; copper also shows a maximum of conductivity, and the same is true of silver and gold, which bear the same relation to Pd and Pt that Cu bears to Ni. On the other hand, the relations of the orbits of V to Ti and of Mn to Cr are of a different nature, though both Mn and V have a single electron in the outermost orbit; there is no maximum of conductivity for either of these elements, and it is suggested that these two facts are interconnected. It is true that, as far as the orbits are concerned, the case of Co as compared with Fe seems to be similar to that of Cu, as compared with Ni, though Co does not show a conductivity maximum. Cr, Mo, and W are high conductivity metals, though the probable number of electrons in their outermost orbits is in each case two. It is possible, however, that this is not actually the case; spectroscopic observations might perhaps show that, in the case of chromium at least, the number is really one, as in the case of the other good conductors. H. N. A.

**2583.** *The Principles of a Theory of Super-Conductivity.* **E. Kretschmann.** (Ann. d. Physik, 74. 5. pp. 405–444, June, 1924.)—In a previous paper [see Abstract 2332 (1924)] the author has derived a general expression for the electrical conductivity of a homogeneous isotropic metal, on the assumption of the random motion of the conducting electrons. The expression involves the mean free path in the direction of the current of independent groups of electrons which are so large that, on the whole, their motion is uninfluenced by the motion of other conducting electrons. The theory is now developed mathematically to explain the existence of the super-conducting state discovered by Onnes. It is shown that the necessary and sufficient condition for the possibility of the existence of this state is that the second differential coefficient with regard to time of the velocity components of an independent electronic group in the direction of the current should, on the average, vanish. Interpreted in terms of the classical theory, this signifies that the electrons must not infiltrate into the region of positive charges. Its significance in terms of the quantum theory is that the electrons must not enter upon the closed quantum orbits of the molecular structures. Reference is made to the variation in the temperature of incidence of the super-conducting state to be anticipated owing to the action of a magnetic field and variation of current density, and to effects attributable to the boundaries of the conductor. J. S. G. T.

**2584.** *Present Knowledge of Dielectric Constants of Electrolytic Solutions.* **P. Walden and H. Ulich.** (Zeits. phys. Chem. 110. pp. 43–56, 1924.)—The question how the dielectric constants of a medium changes under the influence of a dissolved electrolytic substance is inadequately answered by experiments performed hitherto. Not only have such experiments been restricted to a narrow range of liquids with no great variation of type, but even with this restriction the results leave us with no clear view of the matter, since in the course of twenty-five years every possibility has had some experimental support. In the case of older experiments two main sources of error are the inconstancy of wave-length and the strong damping in the exciting circuit, errors which could be eliminated by modern apparatus. In estimating the most probable result of work on aqueous solutions, the authors would give special weight to the values obtained by Drude, using the method of measurement of wave-length, and assume that the dielectric constants of dilute aqueous solutions of strong electrolytes are somewhat lower than that of the solvent. Whether this diminution takes place in the mass of the liquid as the Debye theory supposes is not yet clear, but the idea of a large increase in dielectric constant explained by a departure from the law of mass-action should in any case be rejected. On the other hand, the authors consider it certain that the dielectric constants of solutions of salts in poorly dissociating media is higher than that of the pure solvent, which admits of explanation on the Debye theory by the formation or existence of complex ions. G. A. S.

**2585.** *Electrical Conductivity of Molybdenite.* **J. Okubo.** (Tohoku Univ., Sci. Reports, 12. pp. 299–303, Jan., 1924. In English.)—The resistance of molybdenite decreases with increase of applied potential, and shows two abrupt changes. These occur at well-defined potential gradients, and the values of these for different temperatures are studied. Plotting length of strip against breaking potential for a series of temperatures gives a series of straight lines. The breaking potential falls with increasing temperatures. There is no change in the crystal structure as revealed by X-ray analysis above and below the breaking potential. The conclusion is drawn that the breaks are due to the liberation of electrons and not to intermolecular changes. A. Wh.

**2586.** *The Electrical Conductivity of Molten Caustic Soda.* **K. Arndt** and **G. Ploetz.** (Zeits. phys. Chem. 110. pp. 237–242, 1924.)—The conductivity of molten caustic soda is measured in an apparatus similar to that described [Abstract 1563 (1924)], using a silver crucible. The caustic soda contains sodium carbonate and chloride as impurities. In order to eliminate the effect of these, measurements were made at various temperatures with varying known proportions of sodium carbonate and sodium chloride, the value for pure sodium hydrate being determined by extrapolation. The density of the mixtures being also measured, the equivalent conductivity may be calculated. B. W. C.

**2587.** *Dielectric Constants of Solutions of Electrolytes.* **O. Blüh.** (Zeits. f. Physik, 25. 3. pp. 220–229, 1924.)—The author attempts a quantitative examination of a theory to explain the fact that the dielectric constants of solutions of electrolytes are smaller than that of pure water, making certain simplifying assumptions. It is supposed that in the immediate neighbourhood of each positive or negative ion, in a region identical with the hydration layer, the molecular dipoles of water are polarised by the electric field of the ion, and that the result is that throughout this region the dielectric constant of the water is unity, while in the rest of the water it has the value 81·18, belonging to pure water, in which the dipoles are not polarised. Born has calculated the "apparent" radii of the ions of the alkali metals and of chlorine from experiments on the mobility of the ions; they vary from $2{\cdot}26 \times 10^{-8}$ for lithium to $1{\cdot}11 \times 10^{-8}$ for cæsium. The author assumes values varying from $0{\cdot}45 \times 10^{-8}$ for the true radius of the lithium ion to $0{\cdot}83 \times 10^{8}$ for that of cæsium, and calculates the combined dielectric constant for different concentrations of the chlorides of some of the alkali metals, assuming that that of the water contained in the space between the true radius sphere and that of the apparent radius is unity. The calculated change in dielectric constant for increased concentration is less than that determined experimentally by Sommer; but the relation between dielectric constant and conductivity is linear in both cases (roughly in the case of the experiments), and in both cases the dielectric constant of NaCl falls off more rapidly with increased conductivity than that of KCl, which was the only other salt studied by Sommer. It is also shown that the connection between hydration and dielectric constant can be made use of in the case of colloidal solutions, and may decide the question of the unimolecular adsorption layer. H. N. A.

**2588.** *The Quantum Theory and the Dielectric Constant.* **J. H. Jones.** (Roy. Soc., Proc. 105. pp. 650–661, June 2, 1924.)—Epstein's calculation of the change of energy of a hydrogen atom, when submitted to an electric field, gives rise to a term in the Stark effect which under certain prescribed circumstances, when integrated over unit volume of the gas, becomes identical with $F^2(K - 1)/8\pi$, where F is the field and K is the dielectric constant of the medium. A value of $(K - 1)$ is calculated, from which it is seen that the atom of hydrogen behaves in a uniform electric field like a perfectly conducting sphere of radius equal to that of the first Bohr circle. The value of $K - 1$, according to classical theory, is found to be 5/3 that obtained for the quantum theory. A. B. C. L.

**2589.** *Thermic Variation of Dielectric Constants of Quartz.* **S. Gagnebin.** (Arch. des Sciences, 6. pp. 161–210, May–June, 1924.)—An experimental research with the view of throwing light upon the suggestion (Perrier) that if pyroelectricity and piezoelectricity depend upon a spontaneous dielectric polarisation (analogous to ferromagnetism), there ought to be a dielectric Curie-point at which these phenomena disappear. Results as yet inconclusive. A. D.

**2590.** *Lamps with Several Electrodes in Electrometry.* **P. Lejay.** (Comptes Rendus, 178. pp. 2171–2173, June 23, 1924.)—Development of the method previously described [Abstract 1921 (1924)]. The aim has been to ascertain whether it was possible to make the radium capsules, ordinarily used as collectors, to act directly upon the electrodes of the lamp without modifying the potential of these capsules. It was found possible, with considerable accuracy. A. D.

**2591.** *On the Thermoelectric Properties of Bismuth Alloys, with Special Reference to the Effect of Fusion. With a Note on Thermoelectric Re-Inversion.* **C. R. Darling** and **R. H. Rinaldi.** (Phys. Soc., Proc. 36. pp. 281–287; Disc., 287, June, 1924.)—In this paper the authors describe investigations of the thermoelectric force of couples consisting of Cu and Bi alloyed with varying amounts of (1) Pb, (2) Sn, the determinations in all cases extending beyond the temperature of fusion of the alloy. It is known that Bi and Sb, both of which expand on solidification, show an abrupt change in the thermoelectric power at the point of fusion, and the object of the present investigation was to see whether this change was dependent on the alteration in volume on solidification. The Bi-Pb alloys show only one arrest point on cooling from the molten state, and there is an abrupt change in the thermoelectric power when solidification of the mixture is accompanied by an increase in volume, but not otherwise. The Bi-Sn alloys show two arrest points in cooling, the lower one corresponding to the eutectic. In all cases there is a small change in the thermoelectric power at the eutectic point, this mixture showing a small increase in volume on solidification. At the other arrest point there is only an abrupt change in the thermoelectric power when the Bi is in excess.

A case of thermoelectric re-inversion is also recorded. This occurs when Fe is coupled with an alloy of Bi and Sn (Bi 60 %). If the cold junction is maintained at 0° the e.m.f. is zero when the other junction is at 0°, 200° and 350° C.

In the *Discussion* the chief points raised were the possible influence of the Benedicks' thermoelectrical effect in the molten metal along which there is a temperature gradient and the necessity of repeating the experiments in an inert atmosphere. L. L.

**2592.** *Thermoelectric and Actinoelectric Properties of Molybdenite.* **W. W. Coblentz.** (Bureau of Standards, Sci. Papers, No. 486. pp. 375–418, 1924.)—When molybdenite is heated by thermal conduction or exposed to thermal radiation it exhibits hitherto undescribed thermoelectric, actinoelectric and photoelectric properties. The paper gives precise definitions of these terms. The investigations were divided into three portions under the above headings, and were conducted with molybdenite in the form of thin cleavage pieces, to which were attached fine copper wires to form the thermojunctions. The method used was similar to that previously recorded [Abstract 337 (1919)], and the sample under examination was mounted upon a sliding carriage behind a slit 0·1 mm. wide and 1 cm. long. Thus, by using another slit travelling at right angles to this, any precise spot could be investigated. Light was derived from a tungsten filament lamp. The effects were investigated by the use of both Thomson and D'Arsonval galvanometers.

*Thermoelectrical Properties.*—The first part of the paper shows that, owing to lack of homogeneity, standard thermoelectric data cannot be specified for molybdenite. Samples from various localities, as given in the data, show a range of thermoelectric power against copper from + 700 microvolts, through zero thermal e.m.f., to − 1040 microvolts.

*Actinoelectrical Properties.*—A new actinoelectrical phenomenon is described, consisting of an e.m.f. exhibited in spots or loci of some samples of molybdenite when exposed to thermal radiation of short wave-lengths. Spots separated by only 0·5 to 1·5 mm. will exhibit actinoelectric e.m.f.'s of different polarity. The wave-length of the thermal radiation stimulus determines whether the spectral actinoelectric effect will be photopositive or photonegative. Radiation stimuli of wave-lengths between 0·65 and 0·9$\mu$ give maximum actinoelectrical e.m.f.'s, and wave-lengths greater than 1·0$\mu$ give no effect. The maximum actinoelectric response is apparently instantaneous for all wave-lengths.

*Photoelectrical Properties.*—Photoelectrical effect is exhibited, by the production of a change in resistance when the molybdenite crystal is subjected to an impressed potential and exposed to light. The change in resistance is photopositive or negative according to the wave-length of the stimulating source. The photoelectric reaction is produced by radiation over a range of wave-lengths from 0·3$\mu$ to 2·0$\mu$. The maximum photoelectric response is attained in a time which is a function of the wave-length of the exciting radiation, and is of the order of from one to several minutes. Double this time is required for recovery after exposure. Molybdenite of low resistance, low photoelectric sensitivity and high actinoelectrical sensitivity exhibits spectro-photoelectrical reaction which is apparently instantaneous for all wave-lengths. The effect of temperature, variation of intensity of exciting radiation, etc., are investigated and data given. In general, these factors have no marked effect upon the spectral actinoelectrical reaction or they are the reverse of the effect upon the spectro-photoelectric reaction. A difference of from 1·5 to 2·5 times between the maximum and minimum photoelectric effect is produced when there is a close coincidence of the spots exhibiting photoelectrical and actinoelectrical sensitivity, the photoelectric current being amplified or weakened according to the direction of the impressed potential through the crystals. From the data supplied it may be concluded that the actinoelectric phenomenon is independent of other agencies that may be acting in molybdenite. S. G. B.

**2593.** *Dependence of the Thermoelectric Force of Iron upon its Structure.* **G. Borelius.** (Ann. d. Physik, 74. 8. pp. 757–760, Aug., 1924.)—This paper consists of remarks upon the recent [see Abstract 1910 (1924)] examination and criticism by W. Heraeus of the earlier work of Gunneson and the author. It is contended that Heraeus, by an unfortunate choice of his research material, was led to false conclusions. A. E. G.

**2594.** *The Measurement of Very Small Changes of Capacity.* **R. Gunn.** (Phil. Mag. 48. pp. 224–226, July, 1924.)—While the use of the ultramicrometer according to the methods of Whiddington and of Dowling [see Abstract 2047 (1923)] has proved of great value in the measurement of certain physical quantities, there is still much to be desired from the point of view of convenience, stability, and sensitivity. The object of the present paper is to describe two methods which are direct reading and easy to use. In the first method a valve oscillator capable of supplying about 4 watts at $1{\cdot}5 \times 10^6$ cycles per sec. is loosely coupled to an oscillatory circuit in which the capacity to be measured is situated. This circuit is caused to react on the grid-filament terminals of a second valve. The oscillator is adjusted until resonance is indicated in the test circuit by a flow of current in the anode circuit of the second valve, a microammeter being inserted therein. An auxiliary cell and resistance are used to reduce the current in the microammeter to zero when there is no impressed alternating voltage in the oscillatory circuit. Changes of capacity of the order of $10^{-15}$ farad can easily be detected, this corresponding to a change of 1 microamp. in the anode current.

The second method uses a four-condenser bridge, each arm being about 125 $\mu\mu$F. The bridge is supplied in resonance with an oscillator working at about $1{\cdot}5 \times 10^6$ cycles per sec. The detector points of the bridge are connected to the grid-filament terminals of a valve, in the anode circuit of which is a microammeter with compensating cell and resistance, as before. The bridge must be thoroughly screened from the surroundings and from the valves, and it is then possible to attain a sensitivity of 1 microamp. for a change of capacity of the order of $10^{-18}$ farad in one of the bridge arms. B. H.

## ALTERNATING CURRENTS AND MAGNETISM.

**2595.** *Method of Producing Strong Magnetic Fields.* **P. L. Kapitza.** (Roy. Soc., Proc. 105. pp. 691–710, June 2, 1924.)—The author obtains strong fields by using intense currents for times of the order of 1/100 sec. The source of current is an accumulator made up of 71 plates insulated by rubber buttons and fitted with U-shaped rubber strip, which served to hold the 30 % acid when the plates were clamped together. The plate on one side of a gap was charged positively and on the other negatively, and the whole formed a row of cells in series, with resistance about 0·02 ohm, and capable of giving a current of about 7000 amps. When several such batteries were used a power of about 1000 kw. was obtained for a small fraction of a second. Timed switches are described by means of which the large currents employed were made and interrupted. The currents were measured by a special high-frequency oscillograph (20,000 to 30,000 per sec.) of the Duddell type, and the construction of coils and measurement of their constants are discussed. It is considered that it would be possible to produce a field of the order of 2 or 3 million gauss in a coil of 1 mm. inside diameter. G. E. A.

**2596.** *Magnetic and Electrical Properties of the Ternary Alloys, Fe-Si-C.* **T. D. Yensen.** (Am. I.E.E., J. 43. pp. 558–567, June, 1924.)—This is a general review of the magnetic influence of the ordinary impurities in Fe and Fe-Si alloys. Carbon has by far the most detrimental effect on the magnetic properties (in so far as hysteresis losses are concerned), because even in very slowly cooled material the carbon all exists in solid solution up to about 0·008 %. Carbon above this percentage is precipitated as cementite ($Fe_3C$) or graphite (free carbon). One principal effect of the presence of silicon is that it leads to the precipitation of graphite, and in this form carbon affects the magnetic properties very little. When in the form of free cementite or cementite in the laminated form (pearlite) there is an additional increase in hysteresis losses over and above those due to the trace of carbon in solution. Formulæ are given which enable the hysteresis loss due to carbon (in any of its forms) to be calculated. Of the other impurities sulphur is the most detrimental, manganese in small amounts is harmless, whilst phosphorus is sometimes beneficial.

The magnetic properties also depend to a large extent on the grain size and in particular upon the intercrystalline amorphous cement. The presence of silicon increases the grain size and lowers the amount of amorphous material. As it is concluded that the amorphous cement increases the hysteresis losses in the same way as precipitated impurities, the advantage of silicon is evident. Regarding the tremendous effect of carbon in solution, it is suggested that this is due to the entering of carbon into the more or less stable equilibrium arrangement of the ferro-magnetic structure, which is in consequence deformed. A. A. D.

**2597.** *Elements of Magnetic Analysis.* **E. H. Crapper.** (Engineering, 117. pp. 452–454, April 11; 601–602, May 9; 660–662, May 23; 786–788, June 20, and pp. 816–817, June 27, 1924.)—A useful review of the present state of knowledge of commercial steels, dealing largely with Fröhlich's equations and their applications. Lamont in 1880 introduced the idea of magnetisability in the form $\mu = k(B_s - B)$, where $k$ is a factor, and $B_s$ is the saturation value of B. If $a = 1/kB_s$ and $b = 1/B_s$, Fröhlich's equation may be derived, viz. $1/\mu = a + bH$. Kennelly separated the induction into two parts, that in the iron and that through the intermolecular spaces, or $B = B_i + B_a = \mu_i H + H$. Hence the ferric reluctivity $\rho_i = 1/\mu_i = 1/(\mu - 1)$. By eliminating $b$, the equation $(H + aB_s)(B_s - B) = aB_s^2$ is obtained, which is that of a rectangular hyperbola; a similar equation is obtained for I and H. Steinmetz called $a$ the coefficient of magnetic hardness. The form of Fröhlich's equation,

$H = aB/(1 + bB)$, is the basis of working relationships associated with the design of transformers and other electrical appliances. Watson has employed Fröhlich's equation in the form $(H + H_c)/B = \alpha + \beta(H + H_c)$, and a sample of magnetic material may have its properties expressed by means of three linear equations corresponding to the three portions of the hysteresis cycle. The importance of the demagnetisation curve in reference to permanent magnets is pointed out, and Evershed $\beta\phi$ curves are given for carbon, chrome, tungsten, permanite, cobalt and KS steels. It is further shown that when the constants $a$ and $b$ of Fröhlich's equation correspond to the saturation value of magnetisation, the magnetising field, which gives $\frac{1}{2}I_s$, is $a/b$. Examples are given of the use of Fröhlich's equation, $1/k = \alpha + \beta(H \pm H_c)$, in testing tungsten steels; and since $I_s = 1/\beta$, the effect of varying the amount of the essential element forming an alloy is readily ascertained from the linear equations. This point is illustrated by means of Honda's measurements on iron-cobalt alloys. Steinmetz's equation and the equations for iron losses are next treated, and a method of testing the value of the hysteresis index is described which depends on a measurement of the energy losses in the specimen at two different voltages and frequencies. According to the author's view, the rate of change of magnetic intensity with magnetising force depends on the elastic properties of the material, and a method is given for determining the *magnetic* elastic limit of a magneto magnet, which is measured by the range of demagnetising force which can be applied without removing any of the remanent magnetism. A table of values of the hysteresis constant $\eta$ is given for various magnetic materials. Some of the effects due to magnetic viscosity are described. It is probable that the early sluggish movement of the molecular magnets—frequently termed magnetic viscosity—is due to a number of causes. The variable character of the reluctivity curve is exemplified by means of a graph for a ring of soft iron. The reluctivity at the remanence point is given by the equation $H_c/B_r = (\alpha_1 + \beta_1 H_m)/(\alpha_2 + \beta_2 H_m)$, which is obtained from Sandford and Cheney's equations. This value of the reluctivity is indicative of the ability of the magnet to withstand shocks and the effects of armature reaction. G. E. A.

**2598.** *Electric Fields due to Motion of Tubes of Magnetic Induction.* **L. Kneissler.** (Archiv f. Elektrot. 13. pp. 232–236, July 7, 1924.)—An investigation of this problem by the aid of the vector calculus. A. H.

**2599.** *Deformations of Liquid Streams Carrying Powerful Currents.* **L. Lombardi.** (Rev. Gén. d'Él. 16. pp. 331–337, Aug. 30, 1924.)—Translation of the article referred to in Abstract 152 (1924).

**2600.** *Paramagnetism Independent of Temperature.* **P. Weiss** and **Paule Collet.** (Comptes Rendus, 178. pp. 2146–2149, June 23, 1924.)—Besides the diamagnetic and paramagnetic forms, there is a third type of feeble magnetism, namely, the paramagnetic form, which is constant with change of temperature. This is found in many elementary solids, and the two types of paramagnetism are compared for members of the periodic system from argon to copper. Cabrera showed that the moments of the ions of the iron group, when plotted with the number of electrons in the ion, lie on a regular curve. The authors obtain a curve of similar form by plotting the coefficient of atomic magnetisation as a function of the atomic number for the elements of constant paramagnetism K, Ca, Ti, V, Cr, Mn and Fe. Parallelism of the two curves suggests (*a*) that, for equal numbers of electrons, substances of constant paramagnetism possess the same atomic moments as their ions, and (*b*) the coefficients of magnetisation are proportional to the moments. This leads to the result that in all such substances the interatomic field has the same value, namely, of the order of 300 million gauss. G. E. A.

**2601.** *Ferromagnetism as Affected by Chemical, Thermal and Mechanical Conditions.* **L. W. McKeehan.** (Frank. Inst., J. 197. pp. 583–601, May, and pp. 757–786, June, 1924.)—A survey of existing knowledge of magnetism with a view to testing a quantum theory of magnetism. The close chemical association of Fe, Co, and Ni is one of the most important clues to the cause of ferromagnetism. The theory of atomic structure of Bohr and others makes it clear why the elements in the range of atomic numbers between 21 and 28 should be the first to exhibit magnetic properties, but no reason has been offered to explain why ferromagnetism in solid metals should be confined to the last three of these eight elements, or why it is most conspicuous in the first of these three. With regard to Heusler alloys, it is no accident that manganese and copper are adjacent to the ferromagnetic elements on either side, and the extra electrons furnished by the variable constituent are utilised in some way by the manganese to simulate the structure of iron, cobalt, or nickel. The reversible and irreversible effects of heat and mechanical treatment are also discussed, and some speculations are made as to the form of a quantum theory of ferromagnetism. The evidence for the existence of magnetic quanta in paramagnetic gases is referred to [see Abstracts Nos. 2055 and 2121 (1922)], in which silver atoms have been separated into two groups by a magnetic field. The fact that only one of the 47 extra-nuclear electrons in the silver atom appears to be concerned in its magnetic behaviour implies a high degree of symmetry in the distribution of the angular momenta of the other 46 electrons. The evidence of magnetic structure in ions in aqueous solution is also considered, and internal atomic structures are assigned to the elements with atomic numbers from 18 to 30. The extent to which the proposed structure agrees with experiment is pointed out. A table of 140 references closes the paper. G. E. A.

**2602.** *Spontaneous Magnetisation of Nickel. Lines of Equal Magnetisation.* **P. Weiss** and **R. Forrer.** (Comptes Rendus, 178. pp. 1670–1673, May 19, 1924.)—The value of the "spontaneous" magnetisation $\sigma_0$ may be deduced from thermomagnetic data by plotting the thermal effect $\Delta t$ against the square of the specific magnetisation $\sigma$ for various temperatures [Abstract 1935 (1924)]. In the present paper a curve is given showing the spontaneous magnetisation of Ni as a function of the temperature over the range 20° to the Curie point 357·6°. On the same figure curves are drawn coordinating specific magnetisation and temperature in fields 3228 g, 4116 g, 10070 g, and 17775 g. A second figure shows variation of magnetising field and temperature for equal magnetisation. These lines of equal magnetisation are rectilinear in the stronger fields, apparent and real magnetisation being identical. In the weaker fields there is divergence, the continuation of the rectilinear portion representing the true magnetisation. L. L.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

**2603.** *Recent Results Obtained with the Mass-Spectrograph.* **F. W. Aston.** (Nature, 113. pp. 856–857, June 14, 1924.)—Anode rays of iron have now been obtained strong enough to demonstrate the occurrence of the light isotope 54 previously suspected, the intensity of this line relative to the predominant 56 being estimated roughly as 1 : 20.

*Strontium* consists mainly of atoms of mass number 88, but about 3 or 4 % of a constituent 86 has now been discovered. Accurate comparison between $Sr^{88}$ and $Br^{81}$ indicates that the former is definitely less than a whole number, and gives for the probable mean atomic weight of strontium 87·7, a value higher than the chemical one but not seriously discordant. Search for lighter isotopes of barium is prevented at present by the penumbra of the enormously strong line of iodine, with which parts of the apparatus in use are saturated.

*Lanthanum* and *praseodymium* give single lines of satisfactory strength at 139 and 141 respectively, and are probably simple elements. With neodymium, erbium, zirconium, niobium, and molybdenum indefinite results only are as yet obtainable. T. H. P.

**2604.** *The Effect of Cold-drawing and Annealing on Some Electro-chemical Properties of a Low Tin-bronze.* **S. H. J. Wilson.** (Inst. of Metals, J. 31. 1. pp. 165–175; Disc., 176, 1924.)—This is a continuation of an investigation by Alkins and Cartwright on the variation in physical properties when this material is subjected to successive drawings. [J. Inst. Metals, 26. 205, 1921.] The investigation covers electrical resistance, thermoelectric properties and electro-chemical potential. A critical range is found for these properties similar to that observed by Alkins and Cartwright in the case of tensile strength and density. L. L.

**2605.** *Photoluminescence of Solid Solutions.* **M. Curie.** (J. de Physique et le Radium, 5. pp. 65–83, March, 1924.)—A general review of the facts established by various experimenters during the last twenty years, with the object, if possible, of grouping these facts so as to deduce certain general laws. Solid photoluminescent bodies are in general solid solutions formed by a small quantity of heavy metal (light-producing) dissolved in a solid mineral body, which is a bad conductor of electricity (the diluent). The most remarkable phosphorescent compounds are sulphide of zinc and the sulphides of the alkaline earths. In explanation of the observed facts it is suggested that on account of their low velocity the electrons detached from the luminous source are deviated or arrested on their passage into the diluent, and tend to gather round the electro-negative nuclei of the diluent. These stoppages and these deviations are accompanied by a certain loss of kinetic energy. Consequently the amount of energy set free on the return of the electron to the level of departure (energy of luminescence) may be smaller than the minimum energy of excitation, conformably to Stokes' law. The electrons during their return to the light-producing source would undergo variable losses of energy; they would be placed in fields of force which were not identical, and their kinetic energy would depend to a certain extent on the thermal motion of agitation. Hence the character of the bands of emission with their continuous appearance. The divergences from Stokes' law might arise, according to Einstein's suggestion, from a borrowing by the liberated electron from the thermal molecular agitation. Kowalski has shown that these divergences become very small in liquid air. The electronic theory of the photoluminescence of solid solutions seems well based, but attempts to develop it are difficult, on account of the great condensation of the medium. J. J. S.

**2606.** *On the Viscometry of Colloidal Solutions.* **W. Ostwald.** (Zeits. phys. Chem. 111. 1–2. pp. 62–78, 1924.)—In opposition to the criticism by H. Freundlich of the capillary viscometer for measuring the viscosity of colloidal solutions it is now shown: (1) That the capillary viscometer gives correct viscosity data under defined conditions. For sols which do not obey the Hagen-Poiseuille law values can be obtained by suitable modification of apparatus dimensions which are as well defined as with the Hess instrument. (2) By variations of height or by application of over- or under-pressure, the capillary-viscometer can also be used for measurements of the pressure function of viscosity. (3) That it is possible without difficulty to reproduce by this much simpler and quicker method the most important of the Freundlich and Schalek measurements obtained by means of the complicated apparatus of Hess and Couette, and thereby to demonstrate the validity of the theoretical assumptions made. (4) That it is a definition problem whether only such resistances to motion as obey the Hagen-Poiseuille law can be designated as actual viscosities. (5) That the capillary viscometer is especially suitable, both on theoretical and experimental grounds, for the investigation of colloidal solutions. H. H. Ho.

**2607.** *The Temperature Coefficient of the Mobility of Ions in Liquids.* **F. A. Lindemann.** (Zeits. phys. Chem. 110. pp. 394–398, 1924.)—From a consideration of the collisions of ions of definite charge and mass with solvent molecules of definite mass, the ions and molecules moving with a known velocity, an expression is derived for the mobility of ions at various temperatures. From this the free paths of various monovalent ions are calculated; these are of the right order of magnitude, and a great similarity is observed between the values of $K^+$ and $Cl^-$, $Na^+$ and $F^-$, etc. The free paths for polyvalent ions are much smaller. The temperature coefficient of the migration velocity is assumed to be due chiefly to changes in the free path of the ions. The theory developed above leads to the view that the ions are not hydrated in the sense that water molecules are combined with the ion, travelling as a quasi-rigid entity, but that the ions tend to transfer momentum to the solvent, this causing transference of the solvent in the direction they are travelling, and giving rise to the phenomena usually ascribed to hydration. The lighter ions, such as lithium, will transfer more momentum than the heavier ones. Other well-known facts connected with the mobilities of the ions are discussed with regard to the author's views, which are held to be in agreement with experimental evidence. B. W. C.

**2608.** *Solid Solutions.* **W. Rosenhain.** (Am. Inst. Mining Eng., Trans. 69. pp. 1003–1034, 1923.)—The subject of solid solutions is reviewed and the nature of solid solution crystals discussed. The results of $x$-ray analysis and the arrangement of the space lattices of the crystal are described. The nature and behaviour of intermetallic compounds is discussed and the modification of the properties of a metallic alloy by distortion. F. J. B.

**2609.** *The Influence of Anions on the Passivity of Metals.* **V. Rothmund.** (Zeits. phys. Chem. 110. pp. 384–393, 1924.)—The passivity of nickel and tin is examined by observation of the current-voltage curve, the metal being assumed to become passive at the point where the voltage increases suddenly. Nickel becomes passive in most oxy-acids, the passivity potential, as defined above, being nearly independent of the nature and concentration of the acid. The passivity is also examined in solutions of the halogen acids; the passivity potential in this case is higher than for the oxyacids and differs for different acids. The metal goes into solution in the passive condition. Tin becomes passive in sulphuric, hydrochloric, hydriodic, hydrobromic and fluosilicic acids, but not in nitric acid, iodic acid, or acetic acids. Further, in both the active and passive states it goes into solution as divalent tin. From a brief review of existing theories it is concluded that none of these offers a satisfactory explanation of the described observations, and the influence of the anions on the passivity is an important factor to consider in any attempt to solve the problem of passivity. B. W. C.

**2610.** *Extension of the Gas Law to Superficial Solutions.* **A. Marcelin.** (Comptes Rendus, 179. pp. 33–35, July 7, 1924.)—The results of further experiments on a layer of oleic acid on water [see Abstract 2168 (1924)] show that the product $vS$ of the velocity of propagation and the surface occupied remains sensibly constant as $S$ varies from 2 to 28. Since $pS$ also is constant for values of $S$ lying between 2 and 8, it is evident that the variations of $p$ and of $v$ are proportional, and it seems justifiable to conclude that the constancy of $pS$ holds up to $S = 28$. T. H. P.

**2611.** *Calculation of Heats of Formation and the Interpretation of Certain Exceptions to the Rule of Maximum Energy.* **C. Henry.** (Comptes Rendus, 178. pp. 2248–2250, June 30, 1924.)—The heats of formation of various salts, *e.g.* KCl, NaCl, as calculated from a formula given in a previous paper [see Abstract 1239 (1924)], are compared with observed values. The converse determination of the mean wave-length of the components of the absorption spectra is discussed. Explanations of a chemical nature are presented in respect of exceptions to the rule of maximum energy. A. B. C. L.

**2612.** *Protecting and Sensitising Colloidal Sols.* **E. K. Rideal.** (Cambridge Phil. Soc., Proc. 22. pp. 101–104, May, 1924.)—A description is given of the conclusions of different investigators whereby the protective action of various organic substances on colloidal sols is attributed to selective absorption. In some cases, however, the selective adsorption of a capillary active non-electrolyte leads to increased susceptibility to electrolytes generally or to those of some particular valency, resulting in precipitation of the colloid. Stable colloidal systems are always charged, and disperse systems in water appear in most cases to acquire a constant electrokinetic potential of 70 millivolts. When the electrokinetic potential falls to 30 millivolts coagulation commences, and the rate of coagulation is most rapid at the isoelectric point. On addition of an electrolyte to a suspensoid, both ions of the electrolyte are adsorbed, but one ion, the precipitating ion, is adsorbed more strongly, and it is this excess of one ion which lowers the electrometric potential and produces coagulation. On the addition of a protective colloid to the suspensoid, the adsorption power of the latter for ions is reduced, which may lead to either diminished or increased stability of the colloid, according to which of the ions is most attracted by the protective colloid. J. N. P.

**2613.** *The Migration of the Ions in Solid Electrolytes.* **M. le Blanc** and **M. Kröger.** (Zeits. Elektrochem. 30. pp. 253–255, June, 1924.)—The conclusions of Tubandt [see Abstract 170 (1924)] with respect to the migration of ions with solid lead chloride and silver chloride mixtures, when the migration appears to be confined to one ion only, are criticised with regard to their relation to the known volumes occupied by the respective ions in the space lattice of the crystals. It is also shown that the reasoning of Tubandt fails to explain the observation that the addition of a little sodium chloride to powdered lead chloride causes a considerable increase in conductivity. B. W. C.

**2614.** *Investigations of the Constitution of Strong Electrolytes.* **C. Drucker** and **G. Riethof.** (Zeits. phys. Chem. 111. 1–2. pp. 1–38, 1924.)—A large portion of the paper is occupied with accounts of measurements of the voltage produced by chains of which the following is a typical example :—

$$\overset{-}{\text{Na}}\text{ amalgam} \mid \text{NaCl} \mid \text{KCl sat.} \mid \text{KCl 1/1 norm. HgCl} \mid \overset{+}{\text{Hg}}.$$

In other experiments of the same nature a hydrogen-gold electrode was employed. Combining the results obtained in this way by the authors and by previous investigators with results obtained in freezing-point measurements and conductivity determinations, it is concluded that, in addition to the ions $H^+$, $Na^+$, $Li^+$, $K^+$ and $Cl^-$ in solutions of HCl, NaCl, LiCl and KCl, complex ions are also present. It is impossible that in the case of HCl only complex cathions exist, but for the salts there must be at least one kind of complex anions and one of complex cathions. The number of complex ions must be noticeable with concentrations of about $C = 0{\cdot}01$ mol./litre, otherwise the electrometrical ion curve will be in strong disagreement with the conductivity curve. It is probable that the complex ions are not to be neglected with higher dilution. It may be assumed that the most important complex ions are $Cl_2^{--}$, $Na_2^{++}$, and so on, and that ions like $Li_2Cl^+$ and $LiCl_2^-$ are present, particularly in the case of lithium. In any case, especially when mixed complexes are present, it must be assumed that the undissociated part has a much smaller concentration than has commonly been assumed; it appears indeed to be so small that it can almost be left out of consideration as a fraction of the total concentration (compare Sutherland's hypothesis of total dissociation of strong electrolytes). The agreement of conductivity and freezing-point results must be explained by the fact that, for the first, the values are too high, because not only the ions $A^+$ and $B^-$ but the complex ions are concerned, and for the second they are too high on account of hydratation. H. N. A.

**2615.** *Submerged Corrosion of Iron.* **W. G. Whitman** and **R. P. Russell.** (Soc. Chem. Ind., J. 43. pp. 193T–196T, June 27, and pp. 197T–199T, July 4, 1924.)—The phenomena observed in the corrosion of iron and steel under natural waters and solutions of alkali or non-oxidising acid are capable of adequate explanation electrochemically. Dissolved oxygen takes part in the direct kathode reaction rather than serving as a depolariser for atomic hydrogen as postulated by various authors.

The rate of corrosion under natural waters is determined by the rate of oxygen diffusion to an effective kathode surface and by the protectiveness of the film formed on the metal. The composition and surface condition of the metal are unimportant factors in the corrosion of ordinary steels and iron. Changes in the $p_H$ value of any given water between about 10 and 4·5 do not alter the rate of corrosion, since the liquid against the metal maintains a constant alkalinity owing to the solubility of ferrous hydroxide; the differences in corrosiveness between various natural waters are due to differences in their film-forming tendencies.

Under alkali solutions the rate of corrosion decreases because the rust is more insoluble and hence forms a more protective film; the depletion of hydrogen ions in alkaline solutions is without influence. In non-oxidising acids hydrogen is evolved and the rate of corrosion by this means is largely affected by overvoltage, so that the composition and surface condition of the metal are important factors. Corrosion by dissolved oxygen in acids, as in natural waters, is limited by the rate of diffusion of the oxygen to the surface, and becomes pronounced in weak non-oxidising acids and at high velocities.

The anode and kathode areas may be widely separated or closely adjacent, and any inert area (including rust) in electrical circuit with the corroding anode may act as kathode. Contact with additional kathode area increases the corrosion of iron under natural waters by increasing the area to which oxygen can diffuse. Pitting is due to localised corrosion where the unattacked areas have been partially protected (usually by films), and have therefore acted as kathodes towards the corroding pits.

The direct oxidation theory, like that of colloidal catalytic activity, accounts for only some of the phenomena observed in the submerged corrosion of steel. Each of these theories fails to agree with certain experimental facts, of which two of the more important are the action of copper in contact with steel under natural waters and the similarity in the action of oxygen in natural waters and in acids. T. H. P.

**2616.** *Relative Corrosion of Zinc and Lead in Solutions of Inorganic Salts.* **J. N. Friend** and **J. S. Tidmus.** (Inst. of Metals, J. 31. 1. pp. 177–185; Disc. and Corres., 185–192, 1924.)—The relative rates of corrosion of zinc and lead in solutions of sodium chloride, sodium sulphate, potassium chloride, potassium nitrate, potassium sulphate were determined. Rectangular plates of the metals 3 × 6 sq. cm. were suspended in about 750 c.c. of each of the solutions. The solutions were maintained at a constant temperature in a water bath. After a given time the plates were removed, freed from the deposit by scraping and weighed. The loss of weight was taken as a measure of the corrosion.

It was found that with the exception of the nitrate solution, the rate of corrosion of zinc rises to a maximum and then steadily falls. The point of maximum corrosion is termed the critical concentration for the salt concerned. The fall in corrosion is more pronounced with the sulphates than with the chlorides. The curves for sodium chloride and sulphate solutions resemble in their general form and relative powers of inhibiting corrosion, those obtained for iron under analogous conditions. The curves for lead exhibit the same general features as for zinc and iron, except that the nitrate behaves normally and the retarding action of the sulphates is very pronounced. F. J. B.

**2617.** *First Experimental Report to the Atmospheric Corrosion Research Committee of the British Non-ferrous Metals Research Association.* **W. H. J. Vernon.** (Faraday Soc., Trans. 19. pp. 839–900; Disc., 901–934, March, 1924.)—The results are given (1) of numerous field tests on relatively large specimens of various typical metals and alloys exposed to representative atmospheres, and (2) of laboratory experiments on relatively small specimens, attention being directed to the phenomenon of tarnishing, as distinct from corrosion in the ordinary sense. The types of atmosphere investigated included: (1) An indoor atmosphere continuously unsaturated with water-vapour; (2) an indoor atmosphere of high, and occasionally maximum, humidity; (3) that of an ordinary domestic kitchen; and (4) open air at South Kensington. The methods of examining the tarnish films were: (1) Visual, including microscopic; (2) optical, the diminution of reflectivity furnishing a very sensitive means of estimating the surface changes, especially during the early stages; (3) gravimetric.

For inside atmospheres the relation between weight-increment and time is represented by one of three types of curve: (1) A parabola with its axis coincident with the time-axis of coordinates, the weight-increment being proportional to the square root of the time. In this case the attack of the underlying metal is regulated by the rate of diffusion of the corroding atmosphere through the continuous envelope of scale. Copper, within a wide range of humidity conditions, behaves in this way. (2) A straight line through the origin, the scale being completely permeable and neutral; this is the case with zinc in an unsaturated atmosphere. (3) A parabola with its axis coincident with the weight-axis of coordinates, the weight-increase being proportional to the square of the time. The scale is here discontinuous and accelerates the attack on the remaining metal in proportion to the amount already present. Iron in an atmosphere of relatively high humidity, intermittently reaching saturation, gives a curve of this form.

In some cases an emeried surface tarnishes more readily than one highly polished. Under "inside" conditions the maximum differences occur in the atmosphere of low relative humidity, whereas in the more humid atmosphere "dull" and "bright" surfaces give practically identical results. In the kitchen fine silver develops a greater degree of tarnish on the polished surface, whereas with standard silver-copper alloy (7·5 per cent. copper) the brightly polished surface is relatively immune from attack. Differences in hardness have little influence, but the harder surface sometimes undergoes the greater amount of change. Tarnishing is greater during the winter than during the summer, presumably owing to the greater general pollution of the atmosphere during the winter. This holds, however, only for surfaces initially clean; with copper and copper-rich alloys the rate of tarnishing in the later stages is controlled, within a wide range of atmospheric conditions, by the nature of the tarnish film initially formed.

The change in colour of copper to (1) deep purple, (2) steely or silvery, and (3) yellow, when exposed to an indoor atmosphere of low relative humidity, is accompanied by rapid diminution, and then by slow increase of the reflectivity, and is due to the presence in the air of gaseous sulphur compounds. Solid or liquid particles, including, presumably, sulphur trioxide and sulphuric acid, appear to be without appreciable influence. The presence of liquid water is not necessary, as the action takes place at temperatures above the dew-point and increases to some extent as the temperature is raised. In an indoor atmosphere of variable humidity, occasionally reaching saturation, tarnishing proceeds more slowly. The atmosphere of the domestic kitchen appears to contain a constituent which has a definite inhibiting effect on the capacity of copper for tarnishing. In the open air and in presence of rain copper quickly assumes a light-brown patina, which undergoes gradual darkening during a considerable period; in the early stages the action is not influenced by the ordinary impurities with the exception of arsenic, which hastens the darkening. *Zinc* is highly susceptible to the action of products of combustion, particularly those of coal-gas. The action of an unsaturated, polluted atmosphere on zinc-copper alloys appears in the early stages to be largely a function of the copper content, with which it increases. With 60 : 40 brass the action is at first confined mainly to the α- or copper-rich constituent, but is later concentrated largely on the β- or zinc-rich component, and then produces far more serious results.

The behaviour of iron is fundamentally different, both qualitatively and quantitatively from that of the non-ferrous metals. In the early stages rust forms on isolated spots, which subsequently increase in number and size; the weight-increment-time curve may be either rectilinear or parabolic, according to the conditions, and the actual value of the weight-increment may become relatively enormous.

In an indoor atmosphere polished nickel undergoes characteristic "filming" or "fogging" of the surface if the minimum temperature approaches the dew-point, the difficulty of removing the film increasing with the duration of the exposure. A similar change occurs with nickel-copper alloys, especially in a humid atmosphere, and is a function of the nickel content; true tarnishing takes place more particularly in an unsaturated atmosphere, and is a function of the copper content.

In an unsaturated or more humid atmosphere, free from excessive proportions of products of combustion, copper tarnishes to a much greater extent than silver, but in an ordinary domestic kitchen the reverse obtains. The presence of copper or cadmium in polished silver has a profound inhibiting effect on its capacity for tarnishing; with dull or emeried surfaces there is, however, little to choose between fine silver and the sterling alloy. T. H. P.

**2618.** *Atomistic Mechanism of Metal Rolling.* **U. Kakinuma.** (Phys. Math. Soc. Japan, Proc. 5. pp. 90–105, July, and pp. 150–168, Oct.-Dec., 1923. In English.)—The author gives the results of an investigation on the inner structure of rolled metals based on X-ray data. X-ray photographs of certain metals show the rolling effect, even after annealing for a considerable period. The ill-defined Laue figure, produced from rolled copper, is converted into a more regular one by annealing at relatively low temperatures for a short time, and from an analysis of photographs of the same specimen taken in various positions it is concluded that the atoms of copper tend, in the process of rolling, to attain such a final arrangement that the face-centred cubic lattice is almost regularly oriented with one pair of its cubical faces parallel to the rolled sheet and one of its tetragonal axes parallel to the direction of rolling. A modified view of Hull's analogy regarding the ductility of metals is proposed, with the aid of which the mechanism of plastic deformation is atomistically elucidated. In the case of rolled iron, it is shown that the body-centred cubic lattice should be so oriented that one pair of its cubical faces is parallel to the rolled surface, and one of its face diagonals parallel to the direction of rolling. This is confirmed by X-ray analysis. The lack of definition shown by the patterns of rolled metals is attributed to some form of lattice strain peculiar to each metal, and the nature of lattice strains in copper, iron and silver is discussed. Attention is called to the fact that in the case of iron the lattice strain is complicated, so that the original body-centred cubic lattice appears to be partly converted into a face-centred one, and this may have a close relation to the mechanism of the allotropic transformation of iron from $\alpha$ to $\gamma$ state. A graphical method for the analysis of the patterns of rolled metals is described and applied to the analysis of the photographs of rolled silver, which is found to have a similar structure to that of rolled copper. [See Abstract 396 (1923).] C. O. B.

**2619.** *The Production of Single-Metal Crystals.* **I. Obreimow** and **L. Schubnikow.** (Zeits. f. Physik, 25. 1. pp. 31–36, 1924.)—By a modification of the method of Tammann single crystals of zinc, cadmium, tin, antimony, aluminium, magnesium and copper may be obtained. The metal is melted in a glass tube drawn out to a capillary at one end, heated in a specially constructed electric furnace, the temperature control being very important. The tube is evacuated to prevent oxidation of the metal, and the form of the tube depends upon the property of the metal which is to be investigated, since the crystal takes the form of the glass tube under the conditions of the experiment. The properties of the single-metal crystals are quite different from the properties of the metals in the ordinary form. It is found that the capillary must be less than a definite diameter for each metal in order to produce a single crystal. B. W. C.

**2620.** *Kinetics of Macrocrystal Formation in Tungsten.* **H. Alterthum.** (Zeits. phys. Chem. 110. pp. 1–16, 1924.)—The velocity of crystallisation of tungsten, in the form of compressed rods, was determined. Tungsten powder made by reduction of $WO_3$, was compressed into rods 15 cm. long by 7 × 7 mm. cross-section. These rods were heated to 135° C. for half an hour in a current of hydrogen until sintered. They were then heated directly by passage of an electric current, 1800 amps. at 6 volts, in a current of hydrogen (400 litres per hour being passed) until the melting-point was reached. The crystal boundaries were made visible by etching with a mixture of 30 % potassium ferricyanide and 10 % sodium hydrate solutions. It was found that such a rod showed that several large crystals were formed after two hours' heating. In several hundred batches of material it was found that the germ of crystallisation was formed in times varying from ten minutes to six hours. On longer heating crystal growth took place, the germ crystal increasing in size until the whole rod consisted of a few large crystals.

The number of crystals varied considerably in each batch of material, and in some cases the rod was obtained consisting of one single crystal. The partial pressure of the hydrogen had a considerable influence on the number of crystals. The formation of the germ crystal in rods composed of compressed tungsten powder is the result of several reactions of different velocities. In a batch of material with $10^8$ crystals, $10^5$ are in a favourable position, as they lie on the surface, and of these 10 % lie either near to or on the edges are more affected by the hydrogen. Out of these $10^4$ only $10^2$ are in such a favourable position to each other that their growing force at the maximum possible contact surfaces is able to overcome the resistance inertia of the neighbouring crystals. Ten per cent. of these—that is, ten crystals in all—undergo reduction of intermediate layers more rapidly than the others. This may be due to the existence of fewer intermediate layers from the first. Of this 10 % one or fewer are in a favourable position to provide the first germ crystal. The reduction is retarded by water-vapour, and to such an extent that it will become the determining factor in the total velocity.

F. J. B.

**2621.** *Determination of Critical Ranges of Pure Iron-Carbon Alloys.* **J. F. T. Berliner.** (Bureau of Standards, Sci. Papers, No. 484. pp. 347–356, 1924.)—This is an extension of the work by Burgess and Scott [Abstract 1396 (1916)] on the thermoelectric measurement of the critical ranges of pure iron. The material used was an especially pure series of iron-carbon alloys made from vacuum fused electrolytic iron. Characteristic curves showing the changes in the thermoelectric properties of eight samples varying in carbon content up to 1·54 % are given for temperatures up to 1150°. The $A_2$ transformation was found to be constant at 768° for heating and cooling in all alloys having a carbon content up to 0·45, but it did not appear in alloys of a higher carbon concentration. The characteristics of the curves obtained indicate that the $A_2$ transformation is of a different nature from the $A_1$ and $A_3$ transformations. The temperatures of the $A_3$, $A_2$ and $A_1$ transformations are in fair agreement with those obtained by other methods. The upper end of the transformations is sharp; this is not the case when determined by other methods.

C. O. B.

**2622.** *Influence of Temperature, Time and Rate of Cooling on Physical Properties of Carbon-Steel.* **W. M. Howe, F. B. Foley** and **J. Winlock.** (Am. Inst. Mining Eng., Trans. 69. pp. 722–767, 1923.)

**2623.** *Determination of the Affinity Constants of Bases by the Hydrogen and Quinhydrone Electrodes.* **J. N. Pring.** (Faraday Soc., Trans. 19. pp. 705–717, March, 1924.)—The hydrolysis and affinity constants of a number of amino-bases are determined from the concentrations of hydrogen ions as measured by the hydrogen electrode, the quinhydrone electrode, and in some cases colourimetrically. Pure water and water-acetone mixtures in the proportion 50 : 50 and 10 : 90 respectively are used as solvents. Bases arranged according to their basicity in water follow the same order, with a few exceptions, in the other solvents employed. The nature of the solvent affects both the hydrolysis and affinity constants to an extent which apparently bears no relation to other properties of the solvent, *e.g.* dielectric constant, the value of the constants decreasing rapidly with increasing acetone content. Conductivity measurements for hydrochloric acid and caustic soda were made with the water-acetone mixtures. The dissociation constant of water in these mixtures, determined from e.m.f. measurements, falls off rapidly with increasing acetone content. **B. W. C.**

**2624.** *Dissociation Under a Temperature Gradient.* **P. A. M. Dirac.** (Cambridge Phil. Soc., Proc. 22. pp. 132–137, May, 1924.)—If a gas each of whose molecules is capable of dissociating into two similar molecules be kept at a constant temperature, it will attain an equilibrium state in which the rate at which double molecules dissociate is equal to the rate at which they are formed by recombination of single molecules, there being a different equilibrium state for each different temperature. If the gas be subjected to a temperature gradient, the concentrations necessary for equilibrium will differ at different points. There will thus be diffusion between the two kinds of molecules, a steady state being attained when the rate of diffusion of double molecules into any region is equal to their excess rate of decomposition over their rate of formation within that region. Take the case of a nonconducting tube containing the gas, of unit section, closed at one end, the ends being maintained at different temperatures. There will be a continuous flow of double molecules from the cold to the hot end, where they dissociate and flow back to the cold end, causing a transfer of energy across the sections in addition to that due to thermal conduction. Obviously, then, the temperature gradient will have a maximum value at each end, accompanied by an excess in the concentration of the double molecules at the hot end, and a deficiency at the cold end as compared with the case of no temperature gradient. Hence, if observations could be made of the concentration or temperature gradient at either end, the "velocity" of dissociation and recombination could be calculated in terms of the other physical constants of the gas. The difficulty of making the requisite measurements at the end of the tube is that the quantities to be measured fall off somewhat rapidly, according to an exponential law having a space constant of about 2 mm. under the conditions considered. **G. W. de T.**

**2625.** *Studies in Heterogeneous Equilibria. Part I. Conditions at the Boundary Surface of Crystalline Solids and Liquids and the Application of Statistical Mechanics.* **J. A. V. Butler.** (Faraday Soc., Trans. 19. pp. 659–665, March, 1924.)—Conditions are defined for the establishment of equilibrium between the phases at the boundary surface between crystalline solids and solvents, and the kinetics of these processes are developed by methods of statistical mechanics. The theory is advanced that in the case of a solid in contact with a saturated solution the attractive forces that bind the molecules of a crystal together extend somewhat beyond the surface constituting a field of force which surface molecules must overcome before they can escape, and which attracts molecules of the same kind and so causes the growth of the crystal. The liquid also exerts an attractive force which varies with the distance from the surface. In general, a molecule which passes outwards from the surface experiences first an attraction towards the surface, and after a certain point an attraction into the liquid, while a point of balance exists at which the two opposing attractions are equal. Equilibrium is attained in saturated solutions when equal numbers of molecules pass the balance-point from both sides in any interval of time. From kinetic considerations the following expression is deduced for solubility:—

$$\log_e c = \frac{W_1 - W_2}{RT} - \log_e \frac{AN_0}{1000A'N}$$

where $c$ is the concentration of the saturated solution. $W_1$ the work done per grm. mol. of solute in reaching the balance-point from the interior, $W_2$ the work done per grm. mol. in reaching the balance-point from the surface layer, $N_0$ is the Avogadro number and N the number of molecules in the crystalline surface layer per cm.$^2$. A is given by the expression $\sqrt{R/2\pi M}$ and $A' = \gamma\sqrt{R/W_2\pi}$, where M is the molecular weight of the solute and $\gamma$ its vibration frequency.

Since $W_2 - W_1$ is the total work done by a molecule in passing from the surface into the interior of the liquid, it is equal to the heat absorbed in the process, that is, $Q_v$ the heat of saturated solution. On differentiating the above equation there is obtained the le Chatelier–van't Hoff equation for change of solubility with temperature $d \log c/dT = Q_v/RT^2$.

For the purpose of calculation, $\gamma$ is taken as defined by the characteristic vibration frequency of the solid as determined by "rest strahlen," and for $W_2$ is taken the total heat absorbed in solution or the latent heat of fusion. From the data available in the case of the alkali chlorides a determination is made of the value of the integration constant of the above equation or the term $\log_e AN_0/1000\,A'N$. The values of this constant thus obtained agree in order of magnitude with those calculated from the above equation. J. N. P.

**2626.** *Studies in Heterogeneous Equilibria. Part II. The Kinetic Interpretation of the Nernst Theory of Electromotive Force.* **J. A. V. Butler.** (Faraday Soc., Trans. 19. pp. 729–733, March, 1924.)—The methods developed in the previous paper are applied to the case of a metal in contact with a solution containing its ions. It is shown on kinetic grounds that the Nernst conception of electrolytic solution pressure is capable of accounting for the p.d.'s exhibited by metals in their salt solutions. The case of metals giving rise to one kind of ion is alone considered.

The electromotive process is concerned with the metal ions in the surface layer, those in solution, and the free electrons left on the surface of the metal. The effect of the negative charge is to retard the passage of positive ions away from the surface and to assist their deposition from solution. The charge will accumulate until the two processes occur at equal rates. The condition which is assumed to obtain in the electrolyte in the vicinity of the metal surface is that the metal exerts a force of attraction on the metal ions which falls off rapidly with the distance, while a counter attraction is exerted by the liquid which is greatest at the surface and falls off rapidly with distance. An electrical force of attraction is also exerted on the positive ion which is greatest at the surface and falls off with increasing penetration in the zone of excess positive ions in the solution. The result of the superposition of the three forces is expressed by a curve which possesses a balance-point. A consideration is made of (1) the total work done by the ion in reaching the balance-point from the surface of the metal, (2) that done by an ion in reaching the balance-point from the interior of the liquid in view of the attractive forces and of the p.d. between the balance-point and the interior of the liquid. An expression is derived to evaluate the number of ions which have sufficient kinetic energy to cross the boundary either to or from the surface of metal. By means of these factors an expression is derived in which the normal potential $E_0$ is given by the formula

$$E_0 = \frac{U}{nF} + \frac{RT}{nF} \log_e \frac{AN_0}{1000\,A'N_1} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

and this quantity may be regarded as equivalent to $-\frac{RT}{nF}\log P$ in the Nernst formula $E = -\frac{RT}{nF}\log\frac{P}{p}$.

Some approximate calculations are made in which, as in the previous paper, the quantities involved in the term $A'$, *viz.* $\nu$ and $W'_2$, are given values as before. The values of $\frac{U}{nF}$ are taken from published data, and refer to the total energy change of a complete cell, consisting of the metal electrode combined with the normal H electrode. In the case of a number of metals the potentials calculated on the basis of equation (1) are of the order of magnitude of measured values. J. N. P.

**2627.** *Variation with Temperature of the Photoelectric Effect in Potassium Photoelectric Cells.* **H. E. Ives.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 551–580, April, 1924.)—The photoelectric current from pure potassium in highly exhausted cells was found, contrary to previous belief, to vary with the temperature and in the sense of the temperature change. The temperature range examined was from room-temperature to the temperature of liquid air, and it was found that the temperature variation of the photoelectric current was negligible above 0° C., but became greater the lower the temperature. The change in photoelectric current increases when the frequency of the exciting radiation is lowered. The change occurs in the normal and also in the selective photoelectric effects. The variation with temperature is in consonance with the supposition that the work function of the surface is altered. Such an alteration is shown by the bodily shift along the voltage axis of the voltage-current curve of a photo-sensitive kathode, which occurs when the potassium which is changed in temperature is the anode. On cooling potassium from + 20° to − 180° C. its work function is increased by about $\frac{1}{8}$th volt. J. J. S.

**2628.** *Formation, by a Wet Method, of Layers of Cuprous Oxide endowed with Photoelectric Properties.* **J. Plonchon** and **(Miss) F. Démora.** (Comptes Rendus, 178. pp. 1885–1887, June 2, 1924.)—The experimental study now recorded had its inception in a chance observation relating to effects upon electrodes of abrupt variations of e.m.f. [see Abstract 1126 (1912)]. One of the cells employed contained an extremely dilute aqueous solution of copper sulphate, in which two copper plates were immersed as electrodes, and this having been left untouched and exposed to sunlight for eight days exhibited photoelectric phenomena. The electrodes were found coated with a bluish-red film extremely sensitive to light, and the present investigation studies its systematic production. The requisite dilution is found to range between 1/2000 n and 1/10 n, with an apparent optimum at 1/1000 n. Copper coated electrolytically does not undergo the superficial alteration so rapidly as that with a surface freshly formed by nitric acid immersion and washing. Diffused daylight tends to the formation of an olive-green layer finally. Air is necessary for the phenomenon, as also copper sulphate, since immersion of the copper plates in a full-corked container or in distilled water alone gives no such result. The film is found to be partly soluble in dilute sulphuric acid, and thereby identified as cuprous oxide, which decomposes on acid treatment into copper and cupric oxide. Heated in air, the film is transformed into black cupric oxide. Various photoelectric uses are briefly indicated.

A note by **A. Cotton** draws attention to similar observations by G. Athanasiu. H. H. Ho.

**2629.** *Potentials at Phase Boundaries.* **L. Michaelis** and **A. Fujita.** (Zeits. phys. Chem. 110. pp. 266–284, 1924.)—The conditions at the boundary of two phases containing an electrolyte distributed in equilibrium between them are discussed. From the theory of Nernst, that there is a partition coefficient for the single ions, the active mass of the ions being proportional to their concentration, it is deduced that for a concentration cell of this type the e.m.f. should be zero; also the potential of other cells should vary with the hydrogen ion concentration. Experiments with various concentration cells in benzyl alcohol-water phases show that these requirements are not fulfilled, and that the conception of partition coefficients for each ion must be modified by introducing an "activation" factor. In the case of chemical cells (*e.g.* 0·1 n KCl/0·1 n KI, etc., in the benzyl alcohol water phases) measurements of e.m.f. for various combinations are made giving results which do not appear to be in concordance with accepted theories. The reproducibility of the experiments is not very good. The effect of the diffusion potential is considered in dealing with electrolyte mixtures. It is found impossible to reproduce some experiments of Baur with toluol, who found that the potential at the boundary toluol-water depended upon the hydrogen ion concentration; further, theory requires that the potential of the metal electrode should be constant towards the toluol, e.m.f. measurements measuring only the p.d. at the liquid phase boundary, but the authors' experience does not confirm this view. A modification of the existing theories therefore appears necessary. B. W. C.

**2630.** *On the Theory of the Thermo-dynamic Phase Boundary Potentials.* **E. Abel.** (Zeits. phys. Chem. 110. pp. 587–598, 1924.)—In this paper it is shown that by the distribution of electrolytes between two limited miscible solvents the thermo-dynamic potential at the phase boundaries must be constant, *i.e.* independent of the nature and concentration of the electrolyte. The effective ionic distribution coefficients for given pairs of solvents must be the same for all ions which are equivalent, *i.e.* the so-called specific ionic distribution coefficients. It appears plausible that the latter are equal for all ions, and coincide with the effective coefficients, and that accordingly the relative position of all elements remains untouched with respect to their inertness towards the medium, a thermodynamic phase boundary potential being non-existent. H. H. Ho.

**2631.** *Oxidation and Reduction Potentials of Organic Compounds.* **E. Biilmann.** (Faraday Soc., Trans. 19. pp. 676–691, March, 1924.) —A description is given of the preparation and properties of the quinhydrone electrode and the effect of salts thereon. Quino-quinhydrone and hydro-quinhydrone electrodes are also described. The quinhydrone electrode may be used as a standard electrode and also for the determination of hydrogen ion concentrations, being more convenient in use than a hydrogen electrode. The application of the electrode to the determination of *p*H values in soils is discussed. The reduction potentials of various quinones have been measured with the aid of this electrode, the results being compared with those of American workers. The reduction potentials of alloxanthines have been measured in a similar manner. In the case of azo-compounds it is shown how the equilibrium constants, the heats of transformation and the velocity constant may be calculated from the reduction potentials determined by this electrode. Various possible applications of this in organic chemistry are pointed out.

B. W. C.

**2632.** *Irreversible Electrode Phenomena.* **H. J. T. Ellingham** and **A. J. Allmand.** (Faraday Soc., Trans. 19. pp. 748–771, March, 1924.) —After discussing reversible and irreversible electro-chemical reactions, the experimental facts relating to the kathodic evolution of hydrogen, the anodic evolution of oxygen, electrolytic reductions and oxidations, the kathodic deposition and anodic solution of metals of the iron group, and passivity phenomena as exhibited electro-chemically are correlated and discussed. The value of current-density-potential curves in investigating the problems is pointed out, with the interpretation to be placed upon curves of various types. Irreversible phenomena at small current-densities are discussed, with especial reference to the conditions under which bubbles of hydrogen and oxygen are formed. It is shown that the magnitude of the polarisation produced depends upon the relative velocities of the compensating processes—*e.g.* diffusion or chemical reaction—and the main electro-chemical process, *i.e.* ionic discharge. Polarisation may also be set up by hindrance of the electro-chemical process itself by the formation of a film—solid or gaseous—at the surface of the electrode. The polarisation phenomena reviewed above are explained in the light of these considerations, *e.g.* hydrogen overvoltage is due to the formation of an addition complex with the metal electrode, the compensating processes here being the diffusion of hydrogen into the metal and the reaction $2H \rightarrow H_2$. Passivity may be due to the resistance of an oxide film or thin film of oxygen bubbles to the electro-chemical reaction, various investigators holding different points of view. The detailed nature of the discussions, however, does not lend itself to an abstract. B. W. C.

**2633.** *The Measurement of Certain Inaccessible Potentials with a Controlled Oxygen Electrode.* **A. K. Goard** and **E. K. Rideal.** (Faraday Soc., Trans. 19. pp. 740–747, March, 1924.)—A critical survey of published experiments with the oxygen electrode indicates that the anomalies exhibited are due to the formation of traces of oxide, which are held probably in solid solution at the surface of electrode. The criteria of reversibility of an electrode are discussed. It is shown that, by preparing a platinum electrode of known oxygen content, the potential, when immersed in an arsenate-arsenite mixture, rapidly rises to a maximum value, and then falls away again, the liquid being kept unstirred. The maximum value thus obtained is quite reproducible. Similar experiments were made with various reducing sugars in $K_2CO_3$ solution. The observations in these cases can be satisfactorily explained by considering the reactions between the reducing agent in the solution and the oxide in the surface layer of the electrode. B. W. C.

**2634.** *Electrode Potentials in Non-Aqueous Solutions.* **E. Baur.** (Faraday Soc., Trans. 19. pp. 718–720, March, 1924.)—The use of the capillary electrometer for the determination of electrode potentials in aqueous solutions is discussed with reference to the adsorption of "capillary-active" ions at the phase boundary, this effect being absent for salts, such as the chlorides, sulphates and nitrates of the alkalies. The use of the electrometer for non-aqueous solutions is also described, where there is partition equilibrium between the two phases in the electrolyte. It is shown how these measurements may be applied to measure the interface potentials between inorganic salts in partition equilibrium in non-aqueous solvents, from which the electrode potentials in any solution may be deduced. B. W. C.

**2635.** *Electromotive Equilibrium and Polarisation.* **A. Smits.** (Faraday Soc., Trans. 19. pp. 772–784, March, 1924.)—A critical review of modern theories of passivity and polarisation is given. The hydration theory of Leblanc is rejected, since it assumes the seat of the effects is in the solution itself; the valency theories of Finkelstein and Müller are too indefinite. The retardation of the heterogeneous solution process is the basis of various theories involving the formation of addition complexes of hydrogen and oxygen with the metal electrode; the most general of these is put forward by Foerster, who considers the catalytic effect of hydrogen and oxygen on the retardation of the heterogeneous solution process. The author regards this theory as untenable, since it leads to the assumption that in the passive or polarised state heterogeneous equilibrium does not exist between the metal and liquid in contact with it. In the author's view an internal equilibrium exists in the metal itself between atoms, electrons, ions of different valency, and probably molecules of various sizes. It is the catalytic effect of various agents on the attainment of this internal equilibrium which determines the observed polarisation or passivity phenomena. This affords a simple explanation of the overvoltage of hydrogen and oxygen; also the influence of mercury on the potentials of aluminium and magnesium can only be explained by the above reasoning. B. W. C.

**2636.** *The Mechanism of the Reversible Electrode.* **E. K. Rideal.** (Faraday Soc., Trans. 19. pp. 667–675, March, 1924.)—Modern theories of the origin of e.m.f. in galvanic cells are reviewed. The Nernst chemical theory, as modified by recent workers, is criticised on the ground that it leads to impossible values for the electrolytic solution pressure of the metals. The conception of a series of equilibria in the metal itself, as put forward by Smits in his theory of allotropy, leads to a complex space lattice system for the metal which is at variance with X-ray examination.

On the other hand, the Volta or contact effect alone does not give a complete explanation, since the concentration of the electrolyte has an effect upon the potential of the cell. The "electron affinity" of the metals, calculated from the Richardson thermionic equation or the Einstein photoelectric relationship, follows approximately the same order as the electrode potentials of the metals. By a consideration of the conditions of surface equilibrium of the metal, an expression involving the Volta effect—*i.e.* electron affinity—the electrolytic concentration and the atomic volumes of the elements is derived which is in agreement with experimental observations. This view is preferred to that of Heyrovský, who considers anodic discharge, and only regards OH′ ions as active in causing the electrode potential. A full solution of the problem is impossible until exact information is available on the absolute potential of electrodes immersed in electrolytes of known activity, and on the degree and extent of solvation of the ions. Attention is directed to recent work on both these problems.

B. W. C.

**2637.** *Theory and Practice of the Electrometric Acid Titration.* **F. Auerbach** and **E. Smolczyk.** (Zeits. phys. Chem. 110. pp. 65–141, 1924.)—When in titrimetric analysis the alkali added is plotted as abscissa and the potential of a hydrogen electrode (determined after each addition) or the $p$H$(= -\log_e[\text{H}^\bullet])$ as ordinate, curves are obtained which become very steep when the H$^\bullet$ falls rapidly and the indicator changes colour. The authors show that the curves may be further utilised. The study of the titration of acids (mono-, di- and tribasic), single and in mixtures, leads to equations which enable them to predict the type of curve, its shape as dependent upon the amount of alkali added, the initial volume, the concentrations of acid and alkali, and the dissociation constants of the acid; further, to calculate from the measurements, the dissociation constant of a pure acid and the single concentrations of mixtures, even when the curve does not show characteristic points. The theory is confirmed by experiments made with benzoic, acetic, lactic, tartaric, malic, succinic and citric acids. The use of Biilmann's quinhydrone electrode [see Kolthoff, Abstract 1266 (1923)] in preference to the hydrogen electrode is recommended, and Biilmann's value of the single potential of that electrode is confirmed; quinhydrone is unsuitable in the case of formic acid, however, and the general equations do not hold for oxalic acid, which is too strong. Titrimetric analysis also admits of determining the proportion of the bound acid in the case of mixtures of salts; but for that purpose the concentrations of the single acids should be determined in separate tests.

H. B.

**2638.** *The Determination of Hydrogen Ion Concentrations by Means of the Glass Electrode.* **A. L. v. Steiger.** (Zeits. Elektrochem. 30. pp. 259–263, June, 1924.)—For the determination of the H ion concentration of solutions of many organic liquids which, through disturbing factors, cannot be employed with either the platinum-hydrogen electrode or with indicators, use is made of the glass electrode which was first applied by Haber and Klemensiewicz. The solution is placed in a spherical glass bulb made of Thuringian glass of low melting-point, the estimated thickness of the walls being from 0·02 to 0·04 mm. A platinum wire inserted in this solution forms one of the electrodes. The bulb is suspended in a vessel of potassium chloride solution, to which is connected a standard calomel cell, forming the second electrode. Measurements of p.d. are made by a quadrant electrometer. The two needle sectors are charged to + 100 or − 100 volts. The metal case and one quadrant are earthed, and the potential to be measured is connected to the second quadrant. The deflection produced by 0·0001 volt can be detected. Generally an interval of one hour is required to obtain a stationary potential. As a rule the results obtained can be reproduced to within about 0·0015 volt, and, in the case of solutions of known H ion concentration, are in close agreement with the theoretical values. An investigation is made of the influence of subjecting the glass to treatment by various reagents. A disturbance in the values given is produced by the sodium ion when present in concentrations above 0·2 N. [Abstract 787 (1923).] J. N. P

**2639.** *Processes at the Mercury-Dropping Kathode* **J. Heyrovský.** (Faraday Soc., Trans. 19. pp 692–702, and pp. 785–788, March, 1924.)—*Part I.*—The mercury-dropping kathode may be employed to study the deposition of metals. A sudden increase of current in the current-voltage curve (the decomposition potential) may be caused by: (1) Combination with mercury of the deposited metal and diffusion into the drops; (2) a new phase being formed at the metal surface; (3) diffusion of deposited volatile product into the surrounding solution.

The first case includes metals which form amalgams with mercury. It has been treated in a previous paper [see Abstract 1279 (1923)], and is extended here to zinc, lead and cadmium, the affinity of these metals being determined in volt-farads. The second case occurs if the deposited metals have no affinity for mercury, and experiments with iron and arsenic are described. The third case is dealt with in Part II.

The current-voltage curves obtained are very sensitive to the presence of foreign ions. Waves in the curves appear in very dilute solutions, corresponding to the presence of minute traces of impurities in the deposited metal. Cadmium and lead to the extent of 1 part in 100,000 can be detected in zinc; similarly zinc in cadmium. It is suggested that a complete scheme of qualitative electro-analysis could be devised on these lines, a complete theoretical discussion being given. It is shown that the arrangement may be used to study tri- or tetravalent concentration cells. A study of the phenomena of deposition should determine, in the case of certain metals, whether these exist as a true or colloidal solution. Amphoteric electrolytes may be studied in the same way. The method is limited on one side by the potential of − 2·1 volts, representing the deposition of lithium, and on the other by + 0·2 volt where the mercury begins to oxidise. The method may be adapted to non-aqueous solutions.

*Part II.*—It is the high hydrogen overvoltage of the mercury-dropping kathode which renders this so valuable in studying the deposition of metals. Current-voltage curves for HCl at various dilutions are given representing hydrogen evolution before bubble formation begins. This is an example of the third case quoted in Part I, the hydrogen diffusing into the surroundings of the kathode. From the observations at the mercury-dropping kathode it is concluded that it is the unfavourable conditions for chemical union of the hydrogen atoms to form molecular hydrogen, and not the physical difficulties in bubble formation, which determine the hydrogen overvoltage. The interfacial tension of the drops, which is very sensitive to impurities, shows no evidence for the formation of a surface layer of hydride or a gas film; the regularity of kation deposition affords further evidence against the existence of such layers. In the author's opinion, therefore, it is the influence exerted by the metal in creating favourable or unfavourable conditions for the union of hydrogen atoms which determines the magnitude of the hydrogen overvoltage. B. W. C.

**2640**. *The Nernst Heat Theorem.* **W. H. van de S. Bakhuyzen.** (Zeits. phys. Chem. 111. 1–2. pp. 39–56, 1924.)—In the thermodynamic relation $A = U - T \, . \, dA/dT$, where A is the decrease of thermodynamic potential or the change of free energy, and U the total energy change or calorific value of the reaction, the expression is, by integration, arranged in the form $A = U - T\int_0^T dU/dT \, . \, dT/T + CT$ where C is an integration constant. According to the Nernst heat theorem $C = 0$, so that $A = U - T\int_0^T dU/dT \, . \, dT/T$. The validity of this equation is tested in the case of the following chemical systems: (1) S (rhombic) $\rightleftarrows$ S (monoclinic); (2) $CuSO_4 \, . \, H_2O \rightleftarrows CuSO_4 + H_2O$; (3) $AgI \rightleftarrows Ag + I$; (4) Zn, Hg — $ZnSO_4$ — $Hg_2SO_4$ — Hg (Clark element); (5) other reactions similar to the above involving interaction between metal chlorides or oxides. In the case of systems (1), (2), and (3) use is made of the datum that at the transition temperature $A = 0$. Further, $dU/dT$ is given by the term $c_f - c_p$, or the difference in specific heats of factors and products. Tabulated values are derived for the quantities $1/T \, . \, dU/dT$, $T\int_0^T 1/T \, . \, dU/dT \, . \, dT$ and U, the second of these terms being derived by means of graphical integration. In the case of the sulphur system, curves for the values for U and A are drawn. These curves converge with falling temperature, and when extrapolated meet at a temperature of about 60° abs. when $A = U$. In the case of the systems (4) and (5), A is given by the potential of the cell. The values obtained for U and A in the different cases are compared with those calculated from thermal data and temperature coefficients and also in some cases from data given by determinations of solubility. The hydrogen-oxygen potential is investigated by data given for the cell $H_2 - H_2O - HgO - Hg$ [see Abstract 1636 (1914)]. A comparison is made of the value of the heat of reaction of this cell calculated from thermal data with that derived from the e.m.f. and the temperature coefficient. A calculation is also made of the free energy from the work available when the concentration of hydrogen is brought from a pressure of one atmosphere to that obtaining at the equilibrium stage in the reaction $H_2 + HgO = Hg + HgO$. The calculation of the equilibrium pressure of hydrogen is derived from the change of entropy of the vapour phases in equilibrium with each of the reacting materials. In all instances the discrepancies between measured values of A and those calculated on the basis of the Nernst theorem are of no greater magnitude than would result from the inaccuracy of the data employed. J. N. P.

**2641**. *Influence of Obstructive Films on Anodic Processes.* **U. R. Evans.** (Faraday Soc., Trans. 19. pp. 789–799, March, 1924.)—The considerations of the author lead to the conclusion that the anodic attack of a metal proceeds readily when the product is soluble, and also when it is insoluble, but non-adherent; an adherent insoluble film may stop attack and produce valve-action. The substance is more likely to adhere when it is the direct product of anodic attack than when it is produced by precipitation at a small distance from the anode. Passivity is probably due to a layer of attached oxygen atoms or half-discharged oxygen-rich ions, but the oxide film is not identical with any known massive oxide. There are degrees of passivity. Metals of the B group (Cu, Ag, Au, Zn, Cd, Hg, Sn, Pb) mostly give active, reversible electrodes. Most metals of the A group, which cannot, as a rule, be electrolytically deposited from aqueous solutions, appear to be permanently passive; their electrodes are irreversible and their deposition potentials are far removed from the dissolution potentials. Iron, nickel and platinum, etc., belong to the transition group, with many apparent anomalies. Some experiments of the author on the doubtful relative positions of iron and cadmium are mentioned. When iron is in contact with cadmium in hydrochloric acid, hydrogen is liberated from the iron, and the dissolution of cadmium is accelerated. H. B.

**2642.** *Passivity and Kathodic Overvoltage.* **E. Liebreich and W. Wiederholt.** (Zeits. Elektrochem. 30. pp. 263–279, June, 1924.)—The passivity of a metal depends upon the chemical relations existing between the metal and the surrounding solution; the overvoltage is partly chemical in origin, and therefore some connection between the two phenomena might be expected. In order to investigate thoroughly the passivity of chromium and iron, complete current-coltage curves are taken with the metals, both in the anodic and kathodic conditions. It is shown how changes in direction of this curve will indicate changes in the conditions and chemical reactions at the electrodes. After a description of the necessary apparatus and manipulation, the experimental results are interpreted in the light of the above considerations. Chromium exhibits passivity if the conditions favour the passage into solution of trivalent chromium, the passivity being due to the insolubility of the chromium oxide formed. The passivity of iron is due to the formation of a higher oxide. A small amount of kathodic polarisation is sufficient to activate the metals; hydroxides form owing to the presence of hydroxyl ions in the neighbourhood of the kathode. This is probably caused by the fact that the nascent hydrogen at first is partly used up by reduction of the dissolved oxygen to water, and partly adsorbed by the metal electrode. Hydrogen is only evolved as such when the metallic hydroxide is completely reduced.

Various current-voltage curves are illustrated and discussed for active and passive chromium and iron, a satisfactory chemical explanation being deduced in all cases. The detailed nature of this work does not lend itself to an abstract. Similar curves were obtained for mercury; in passing from the anodic to the kathodic condition the nascent hydrogen must be used up at first in reducing the oxide film before it can be evolved freely. The bearing of this on the kathodic overvoltage of mercury is pointed out, the adsorption of hydrogen by the metal being a deciding factor. A review of previous experiments on the deposition of gold and chromium, when complete current-voltage curves were taken, indicates that the kathodic deposition of metals may be influenced by the alloying properties of the metal deposited and the metal kathode, analogous to the adsorption of hydrogen by the metal kathode. B. W. C.

**2643.** *Measurement and Cause of Overvoltage.* **S. Glasstone.** (Faraday Soc., Trans. 19. pp. 805–816, March, 1924.)—The author believes that the "transfer" resistance of Newbery [Abstract 477 (1920)], which he would call surface resistance, is due to a metal gas-electrolytic system at the surface of the electrode, and he discusses various sources of error in overvoltage measurements. He finds that the overvoltage, as determined by the direct method, depends, for a given current-density, upon the size of the electrode, decreasing as the electrode becomes smaller. At very low current-densities, however, the direct method is the only one available; in other cases he prefers his extrapolation method. A theory of kathodic overvoltage, based upon some experiments with kathodes of Hg, Cu and Pb, is outlined. H. B.

**2644.** *The Gas Film Theory of Overvoltage.* **N. V. S. Knibbs.** (Faraday Soc., Trans. 19. pp. 800–807, March, 1924.)—Critically reviewing current theses, the author suggests that the overvoltage is the fall of potential across the gas layer adsorbed to the electrode surface, the thickness of the layer being dependent on the nature of the electrode surface (its adsorptive power), the facility with which bubbles are formed (depending on the presence or absence of nuclei and on temperature and pressure), and the current density (which controls the quantity of gas to be evolved and hence the rate of bubble formation). The gas layer is stable on account of the forces of adsorption. When the thickness exceeds a certain limit, the forces on the outer layer become very weak, and a bubble forms. According to MacInnes and Adler [Abstracts 359 and 973 (1919)], the formation of a bubble requires more energy than that required to make it grow; at very low current-density the overvoltage varies periodically with the formation and release of gas bubbles. Colloids modify the overvoltage because they influence the adsorptive power of the electrode. Various peculiarities are discussed from this point of view, but the author only deals with kathodic overvoltages. H. B.

**2645.** *Conductivity of Fused Electrolytes.* **W. Biltz** and **W. Klemm.** (Zeits. phys. Chem. 110. pp. 318–342, 1924.)—The conditions are investigated for obtaining accurate measurements of the conductivity of fused metal chlorides. A sinusoidal alternating current of 500 periods at 4 volts is adopted, and a bridge arrangement and telephone are used. A quartz U-tube fitted with platinised platinum electrodes is employed, as containing vessel and access of water is excluded. The capacity is determined by calibrating with potassium chloride solution. The influence is determined on the conductivity values of fused salts of varying the capacity of the cell and the form of the electrodes, whether of disc, cylindrical, or spherical shape. With disc electrodes the specific conductivity increases with the capacity, but reaches a limiting value which agrees with that given by the other forms of electrodes. A comparison is made of the results with earlier data by Arndt [Abstract 1129 (1906)] and by **Jaeger.** In the case of the alkali chlorides the specific conductivity values for the fused salt at temperatures near the m.p. are as follows: LiCl 5·94, NaCl 3·56, KCl 2·19, RbCl 1·55, CsCl 1·14. The molecular conductivity $\mu$ is taken as the product of the specific conductivity and the molecular volume as derived from the density. The values of the molecular conductivity at the m.p. bear a relation to the atomic volume $v$. In the case of the alkali chlorides the product $\mu v^{2/3}$ gives an approximately constant value, similarly with the chlorides of the alkaline earth metals, while in the case of those of Ag, Cd, and Bi the value is much lower. The values for the specific conductivities are classified according to the periodic system of the elements. Results are plotted for the change of specific conductivity with temperature. Except in the case of $ZnCl_2$, which, of the compounds measured, has the lowest value for the conductivity, the curves obtained are slightly concave to the temperature axis and approximately parallel to each other. The temperature increments of conductivity are thus similar and independent of the absolute values. The temperature coefficients accordingly increase with falling absolute value of the specific conductivity. J. N. P.

**2646.** *The Electrodeposition of Manganese. Part I.* **A. J. Allmand** and **A. N. Campbell.** (Faraday Soc., Trans. 19. pp. 559–570; Disc., 571–573, March, 1924.)—The authors describe experiments made under various conditions with solutions of manganese sulphate and chloride, partly on the lines of (not numerous) previous investigations, notably of Grube and Metzger [Abstracts 1495 and 1702 (1923)], and van Arsdale and Maier [Abstract 822 (1919)]. High metallic salt concentration, low hydrogen-ion concentration and high current-density appeared advisable. Neutral baths containing the sulphates of manganese and ammonium (not sodium) gave pure metal deposits, not contaminated with basic material, at 30° C. and a kathodic current-density of 10 amps./dm.$^2$, but not more than a few grammes of coherent manganese could be obtained, and the current-efficiency was 40 to 50 per cent. In reply to questions the authors agreed that the exfoliation of the deposits was probably due to occluded hydrogen; but the brittleness of the manganese seemed to have another cause, as it did not disappear when the metal was heated *in vacuo* to 300°. H. B.

**2647.** *Influence of Temperature on the Polarisation of Nickel.* **S. Triandafil.** (Comptes Rendus, 178. pp. 1973–1975, June 10, 1924.)—It is known that polarisation diminishes with a rise of temperature; also that it increases with the voltage and current-density until it reaches a limiting maximum value. The author has measured the total polarisation with nickel electrodes in nickel sulphate and nickel chloride at various temperatures with various current-densities, a limiting value being observed in each case. If this value is plotted against the temperature, it is seen that the total polarisation falls off with increasing temperature, the rate of decrease becoming constant between 25° and 100° C. Similar curves are obtained with both electrolytes, and chloride giving a value 1·38 volt higher than the sulphate from 0°–100° C. B. W. C.

**2648.** *Electrolytic Protective Oxide Coating on Aluminium.* **A. Günther-Schulze.** (Zeits. f. Metallkunde, 16. pp. 177–178, May, 1924.)—When an aluminium anode is placed in borax solution the oxide film increases the p.d., originally of 5 volts, to 150 volts by the time the film has a thickness of $0\cdot 1\,\mu$, and to nearly 500 volts when the film thickness is $1\,\mu$. For most protective purposes the former tension is sufficient.

The treatment by d.c. or a.c. (with two aluminium electrodes) will take one or two hours, during which the temperature of the cell should not exceed 50° C. The washed and dried surface may profitably be covered with paint afterwards. H. B.

**2649.** *Catalytic Electrolytic Generation of Oxygen.* **C. G. Fink.** (Indust. and Engin. Chem. 16. pp. 566–567, June, 1924. Paper read before the Am. Chem. Soc., Jan., 1924.)—A brief discussion of anodic electrolytic corrosion is given, with especial reference to the characteristics of insoluble anodes for technical electrolysis. It is pointed out that it is the velocity of discharge of the anions to form gaseous oxygen, compared with the velocity of combination of the anion with the metal of the anode which determines the solubility of the metal under the action of a current. An anode, in order to be insoluble, should therefore catalyse the formation of gaseous oxygen as far as possible, *i.e.* reduce the oxygen overvoltage. Metals which form two or more oxides, or metals which form insoluble surface compounds in a porous condition, might be expected to produce this effect. Experiments show that barium, manganese, cobalt, lead and silver are satisfactory metals for the purpose. B. W. C.

**2650.** *Anodic Gold Oxidation.* **F. Jirsa** and **H. Jelinek** (Zeits. Elektrochem. 30. pp. 286–289, June, 1924.)—By means of the equilibria in the solubility of auric hydroxide in sulphuric acid of varying concentrations a determination is made of the solubility product of this hydroxide. On account of the low rate of solution of the oxide in dilute sulphuric acid, the method followed consists in taking saturated solutions of the oxide in concentrated acid, diluting to varying degrees, allowing to stand until equilibrium is attained, and estimating the concentration of dissolved oxide and acid. From the constant given by the expression: $K = [Au^{\cdot\cdot\cdot}]/[H^{\cdot}]^3$, the value of the solubility product of the hydroxide is estimated to have the value: $[Au^{\cdot\cdot\cdot}] \times [OH']^3 = 9{\cdot}0 \times 10^{-46}$. From this value it is evident that weak acids of low H ion concentration are not able to form any $Au^{\cdot\cdot\cdot}$ salt since this is practically completely hydrolysed. A measurement is made of the p.d. of the element:

$$\underset{\text{(saturated solution of hydroxide)}}{Au/1n\gamma H_2SO_4}/1nH_2SO_4/H_2 . Pt$$

and from this the normal potential $OE_h Au \rightarrow Au^{\cdot\cdot\cdot}$ is found to have the value $+ 1{\cdot}39$ volt. From measurements of the values for E of the concentration element,

$$Au/\underset{c_1}{Au_2(SO_4)_3}/\underset{c_2}{Au_2(SO_4)_3}/Au$$

evidence is obtained to show that gold in a solution of auric sulphate is preponderantly in the form of $Au^{\cdot\cdot\cdot}$. J. N. P.